THE
BREWER, DISTILLER,
AND
WINE MANUFACTURER

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BREWER, DISTILLER, AND WINE MANUFACTURER

GIVING FULL DIRECTIONS FOR THE MANUFACTURE OF BEERS, SPIRITS, WINES, LIQUEURS

ETC. ETC.

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EDITOR'S PREFACE.

In the compilation of the present volume the standard and latest works of reference have been consulted, in addition to which the sheets have been subjected to revision by gentlemen having practical knowledge of the subjects treated therein. The best thanks of the Editor are due to his friends Mr. T. A. Pooley, B.Sc., F.C.S., &c., and to Mr. W. Harkness, F.I.C., F.C.S., &c. —to the first for his able assistance and collaboration in the Chapter on "Brewing"; and to the second for his valuable services in revising the proofs of the Chapters on "Alcohol" and "the Distillation of Alcoholic Liquors." Furthermore, since it has been the aim of the Editor to render the book concise without sacrificing any detail of value, he is led to hope it will be found a convenient, reliable, and useful Manual for the Brewer, the Distiller, the Wine Maker, and the Liqueurist.

JOHN GARDNER, F.I.C., F.C.S.

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THE BREWER, DISTILLER

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WINE MANUFACTURER.

CHAPTER I.

ALCOHOL.

Syn.—Ethylic Alcohol. Hydrate of Ethyl, C_2H_6O. —A term commonly applied to one kind of spirit—that obtained by the distillation of any fermented saccharine liquid, and forming the characteristic principle of wines, beers, spirits, and other intoxicating liquors.

Kohol, a Hebrew-Syriac word, was the name given to a preparation of powdered antimony used by Oriental ladies to paint their eyebrows. In course of time this term was applied to other fine powders, and ultimately to highly rectified spirits.

Although the art of distillation was probably known at a comparatively early age of the world, the preparation of pure rectified spirit does not appear to have been accomplished until the thirteenth century, when Raymond Lully first devised the method of concentrating the spirit obtained from wine by means of carbonate of potash; after which date it gradually became an article of trade and commerce in Europe. About 1760, Dr. Black obtained alcohol of sp. gr. 0·800 by treating spirit with calcium chloride, and

Richter afterwards procured it of so low a sp. gr. as 0·796 at 60° Fahr.* Lavoisier demonstrated the composition of alcohol about the year 1780. Its analysis, first effected by M. Saussure, jun., was confirmed by MM. Dumas, Boullay, Gay-Lussac, and by later chemists.

Dilute alcohol may be procured, by the ordinary process of distillation, from all fermented liquors. When procured from wine (as in France), it constitutes BRANDY; when from the refuse juice of the sugar-cane, it is called RUM; when from malt, grain, or molasses (its chief sources in England), it is called MALT, RAW-GRAIN, or MOLASSES SPIRIT; and when from rice or palm-wine, ARRACK. Brandy, rum, hollands, and whisky contain about half their volume of alcohol; and gin much less. When distilled from any of these spirituous liquors, the alcohol contains, besides water, variable quantities of essential oils, ethers, and other flavouring matters, which it for the most part loses after one or more redistillations with charcoal or lime. It then becomes commercial spirit of wine. By a further rectification from chloride of calcium, lime, carbonate of potash, or any other substance having a strong affinity for water, the water is retained, and a strong spirit passes over containing not more than 10 per cent. of water. By repeating the process, and using the proper precautions, it may be obtained almost entirely free from water, and it is then called absolute or anhydrous alcohol.

Preparation. **I. Absolute Alcohol**:—*a*. Highly rectified spirit, of 85 per cent. (sp. gr. 0·835 to 0·822), is mixed, in a tubulated retort, with about half its weight of freshly-burnt quick-lime, in coarse powder; and the whole, after securely stopping the neck of the retort with a cork, and being well shaken, is allowed to repose for several days.

* Crell's *Annals*, 1796.

The alcohol is then carefully distilled off, drop by drop, by the heat of a water bath, until the weight of the distillate nearly equals that of the anhydrous alcohol in the spirit operated on. The sp. gr. of the product should be 0·795 or 0·796; but by carefully repeating the process with the distillate and a fresh quantity of lime, and prolonging the last digestion with the latter for twelve weeks, absolute alcohol of the sp. gr. ·79381 at 60° Fahr. may be easily obtained.

b. (DRINKWATER; FOWNES.)—The strongest rectified spirit of wine is digested in a stoppered bottle for several days, with about half its weight of anhydrous carbonate of potash in powder,* frequent agitation being had recourse to; the alcohol, after repose, is then decanted, and treated with sufficient freshly-burnt quick-lime to absorb the whole of the spirit. After forty-eight hours' digestion, the spirit, when distilled, will have the sp. gr. 0·793 at 60° Fahr.

c. (LIEBIG; URE.)—Alcohol of about 90 per cent. saturated with fused chloride of calcium,† in powder, and after repose for a few hours in a stoppered bottle, is submitted to distillation as before. The product should nearly equal the quantity of dry alcohol in the sample. Ure recommends equal weights of the spirit and chloride to be taken; and the process to be stopped as soon as about half the volume of the spirit employed has passed over, or until the distillate acquires a higher sp. gr. than 0·791 at 68°, or 0·796 at 60° Fahr.

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* The carbonate of potash must be made anhydrous by exposure to a red heat; when cool, it should be reduced to powder, and added at once to the spirit.

† Calcium chloride possesses the disadvantage of combining with the alcohol and forming a compound from which the alcohol can only be separated at a temperature so high as to decompose it into olefiant gas and water. Towards the end of the distillation it is also liable to give off aqueous vapour which dilutes the alcohol by passing over with it.

d. (Poggendorff.)—Saturate alcohol with caustic potash, then add half its volume of water, and distil at a low temperature.

e. (Graham.)—Freshly-burnt and coarsely-powdered lime is so arranged in a large shallow basin as to expose as great a surface as possible. Upon the lime is placed a smaller basin, containing commercial alcohol, in the proportion by weight of one of alcohol to three of lime. Both dishes, with their contents, are then placed under an air-pump, and exhaustion commenced and continued until the spirit just begins to boil. Not less than six days are necessary to ensure its greatest condensation. Graham found that a spirit having a sp. gr. 0·827, at the end of this time, yielded alcohol of sp. gr. 0·796.

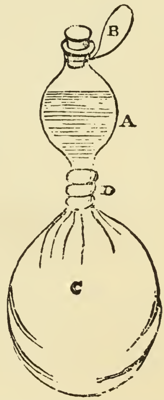
II. **Hydrated** or **Commercial Alcohol**:—*a.* (Without distillation.) Rectified spirit is agitated, in a close vessel, with anhydrous carbonate of potash (prepared by heating the salt to redness, and still slightly warm) until the powder sinks to the bottom undissolved; the carbonate is then added in considerable excess, and the agitation repeated at short intervals for some hours, or even days; lastly, after sufficient repose, the clear upper portion is decanted. If a clean spirit, and pure carbonate of potash (perfectly free from caustic potash or any other impurity soluble in strong spirit) be used, alcohol sufficiently pure and free from water for many common purposes may be thus obtained; otherwise the product contains a little potassa, &c., which can only be removed by distillation. For some purposes, however, this would not be objectionable. Sp. gr. about 0·812.

b. The Rectified Spirit of the British Pharmacopœia, 1867, contains 84 per cent. of anhydrous alcohol, and has a sp. gr. 0·8382 at 60° Fahr. It is used in preparing the official tinctures, spirits, extracts, &c.

III. (Soëmmering.—**Varnish-maker's alcohol.**) The

bladder of an ox or calf, thoroughly cleansed from fat, and washed and dried, is nearly filled with rectified spirit and then securely fastened and suspended in any dry situation, at a temperature of about 122° Fahr. In from six to twelve hours, when the heat is properly maintained, the spirit is generally sufficiently concentrated, and in a little time longer is rendered nearly anhydrous or free from water, or of the strength of 96 to 98 per cent. The same bladder will serve for more than one hundred operations. If not kept very nearly full, a portion of the spirit escapes through the empty part. To prevent this accident, a bottle with a double neck, of the shape represented in the engraving, may be employed; by which means the bladder may be kept constantly full during the process. After the first or second time of using, the bladder gives alcohol sufficiently pure for all ordinary purposes. Before hanging the apparatus up, it is better to enclose it in a coarse potato-netting, to prevent any accident arising from the strain on the neck of the bladder. Soëmmering recommends both the inside and outside of the dry bladder to be smeared over two or three times with a strong solution of isinglass, but this is not necessary to the success of the operation.

Fig. 1.



A, A bottle with two necks, the upper furnished with a ground-glass stopper.
B, Loop of cord by which to hang the apparatus up.
C, Bladder, containing spirit, filled by means of the bottle *A*.
D, Neck of bladder accurately secured to the under neck of the bottle *A*.

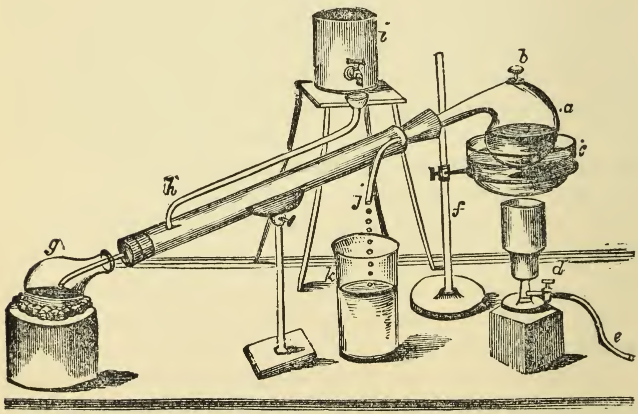
Divergent results have been obtained by those who have practically investigated the above process, for whilst Graham by a slight modification of the method, succeeded in considerably concentrating the spirit, other chemists, employing

alcohol of varying strength, obtained a weaker instead of a stronger spirit, unless they used a very dilute alcoholic solution, in which case the increase of strength was then very insignificant.

The selection of any one of the processes given above for the preparation of alcohol must greatly depend on the convenience or position of the operator.

Chloride of calcium, and quick-lime, from their powerful affinity for water, and easy application, are the hygrometric substances most generally employed; but the processes involving the use of the other substances and methods already noticed, have all of them advantages under particular circumstances. GAY-LUSSAC has recommended the use of caustic baryta instead of lime; and others have employed dry alumina, as an absorbent of the water prior to distillation. Common proof spirit may be concentrated until its sp. gr. falls to about 0·825, by simple distillation in a water bath;

FIG. 2.



at which sp. gr. it contains only about 11 per cent. of water, by weight, and is then nearly as volatile as pure alcohol.

A convenient apparatus for the preparation of alcohol, on the small scale, is that figured in the engraving. The tank (*i*) should be supplied with ice-cold water; and the receiver (*g*) should be covered with cloths kept continually wet with water at the same temperature. The capsule or basin (*c*) is a water bath heated by the little gas furnace (*d*). *a* is the retort, *b* its tubulure, *f* a stand acting as a support to *a*, *h* a pipe for keeping up the supply of cold water to the Liebig's condenser, *j* ditto for removing the warm water which flows into *k*.

By surrounding the capital of a still, or other similar apparatus, by a water bath kept at the proper temperature, the alcoholic richness or content of the product may be regulated to the greatest nicety, for any desired strength.

The divergent statements of chemical authors as to the boiling point, specific gravity, &c., of alcohol, may be referred to their having either experimented with samples which have not been absolutely anhydrous, or to their not having made the proper corrections for temperature, and for the different materials of which their vessels and instruments were composed—some probably having been made of glass, and others of brass or some other metal. In some instances the differences are more apparent than real, as in the Tables by TRALLES and LOWITZ; in the former of which water, at its lowest sp. gr., is taken as the standard.

BERTHELOT obtained alcohol synthetically by dissolving olefiant gas in the strongest sulphuric acid, diluting the mixture with water, and submitting it to successive distillations. He eventually procured it in the anhydrous state by digesting it after each distillation with fused potassium carbonate. The product was identical in every respect with ordinary alcohol. Nearly thirty years previous to Berthelot's discovery, HENRY HENEL found that pure olefiant gas is absorbed by agitation with concentrated sulphuric acid, with

the formation of sulphovinic acid, and that by subsequent dilution with water and distillation, alcohol passes over into the receiver.

SAYTZEFF has obtained ethylic alcohol in large quantities by treating acetyl chloride with glacial acetic acid in the presence of sodium amalgam. The following is his method of proceeding:—Solid sodium amalgam finely divided, and consisting of 100 parts of mercury and 3 parts of sodium, is placed in a flask fitted to the lower end of a condenser and immersed in ice-water. To $1\frac{1}{2}$ molecules of the sodium, a mixture of 1 molecule of acetyl chloride and 2 molecules of acetic hydrate is taken, and is gradually poured upon the amalgam, the contents of the flask being constantly agitated, either by shaking or by a glass stirrer passed through the cork. After running in all the mixture, the flask is kept in motion until its contents become a solid mass, when it is set aside for twenty-four hours. Water is then added, and the mixture distilled until oily drops cease to come over with the water. The distillate consists of two layers, the upper of which has a strong odour of acetic ether. This is decomposed by concentrated solution of potash; and an alcoholic fluid is then distilled off, which, after rectification and drying, is anhydrous ethylic alcohol.

A modification of the above process is that by LINNEMANN, who, dispensing with the use of acetyl chloride, obtains ethylic alcohol by acting on glacial acetic acid with sodium amalgam; the resulting product is separated from the oily matter by filtration, and the mixture being neutralized with anhydrous potassium carbonate, and rectified in the customary manner, ethylic alcohol passes over.

M. ZETTERLAND* states that he has obtained alcohol from sawdust by the following process:—Into an ordinary steam-

* *Chemical News*, xxvi. 181.

boiler, heated by means of steam, were introduced 9 cwt. of very wet sawdust, 10·7 cwt. of hydrochloric acid (sp. gr. 1·18), and 30 cwt. of water; after eleven hours' boiling there was formed 19·67 per cent. of grape sugar.

The acid was next saturated with chalk, so as to leave in the liquid only a small quantity (½ degree by LUDERSDORF'S acid areometer); when the saccharine liquid was cooled down to 30°, yeast was added, and the fermentation finished in twenty-four hours. By distillation there were obtained 26·5 litres of alcohol of 50 per cent. at 15° Cent., quite free from any smell of turpentine, and of excellent taste. It appears that the preparation of alcohol from sawdust may be successfully carried on industrially when it is precisely ascertained what degree of dilution of acid is required, and how long the liquid has to be boiled.

If all the cellulose present in sawdust could be converted into sugar, 50 kilos of the former substance would yield, after fermentation, 12 litres of alcohol at 50 per cent.

Alcohol from Madder Root.—A serviceable spirit for various technical purposes has lately been extensively manufactured in France, and to some extent in Glasgow, by a patented process, the invention of a M. JULLIEN. By this method, the saccharine matter contained in the madder, which, being detrimental to its tinctorial qualities, was formerly allowed to run waste, is now utilized as a source of alcohol. Being first dried and ground to a coarse powder, the root is placed in vats, and infused in water at the ordinary temperature until it has parted with all its saccharine matter. The saccharine infusion, which is then run off through strainers, leaving behind the root (which being again dried and ground, is then ready for use by the dyer), is eventually conveyed into the fermenting tun, and mixed with the several washings from the infusion vats. No yeast nor artificial heat is necessary to start the

fermentation, which is soon spontaneously set up. When the liquid has reached a proper attenuation it is at once run into the still, the distillation being conducted the same as for ordinary grain spirit. In practice, 2 tons of madder give 2500 gallons of wort, having a density equivalent to 30° by Allan's saccharometer.

Properties.—Alcohol is a light, transparent, colourless fluid, very mobile, highly volatile and inflammable, and burning with a pale blue and smokeless flame, when hydrated, but with a whitish flame, depositing carbon on a cold body, when anhydrous. It has an agreeable odour, and a strong and pungent taste. It mixes in all proportions with water, with the evolution of heat, and temporary expansion, but ultimate condensation* of the mixture, some hours elapsing before the union is complete and the normal temperature is restored. The mixture has a higher specific gravity than the mean of its constituents; and this, according to Rudberg, is greatest when 53·739 volumes of alcohol are mixed with 49·836 volumes of water at 59° Fahr., the resulting compound measuring only 100 volumes, and having a specific gravity of 0·927. Alcohol has a very great affinity for water, hence it should always be kept in closely-stoppered bottles. It dissolves resins, such as copal, mastic, sanderac, and shellac, essential oils, camphor, bitumen, soaps, carbonic and boracic acids, iodine and the iodides, bromine with the formation of hydrobromic acid and bromal, lime, ammonia, soda, potash, the alkaloids, and, when boiling, wax and spermaceti, and all the deliquescent salts, with the exception of carbonate of potash.

Alcohol absorbs many of the gases. According to Saussure, 1 volume of alcohol, sp. gr. 0·84, is capable, at the

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* This only occurs when the water is present in certain proportions; when it exceeds these, the mixture undergoes sensible expansion.

temperature of 64° Fahr., of absorbing 115·77 volumes of sulphurous acid gas. Of hydrochloric acid gas it absorbs nearly seventy times its volume, the mixture, when boiled, giving off chloride of ethyl; it also absorbs chlorine very readily, with the formation, if the action be kept up for any length of time, of chloral. Ammoniacal gas is absorbed by it nearly as greedily as by water. It curdles milk, coagulates albumen, and, when used in sufficient quantity, separates the starch and gum from mucilages containing these substances. It boils at 173·1° Fahr. when anhydrous. When diluted with water, its boiling-point rises in proportion to the amount of water added. It boils in *vacuo* at 56° Fahr. Every volume of boiling alcohol yields, at 212° Fahr., 488·3 volumes of vapour: the elastic force of its vapour is therefore very great. Its specific gravity, according to KOPP, at 60° Fahr. is 0·7939, that of its vapour being 1·6133. Alcohol has never been frozen. When cooled to −166° Fahr. it becomes of the consistence of castor oil, but does not solidify; hence it is especially suited for thermometers registering very low temperatures. Between −15° and +99° Fahr. it expands with great regularity at the rate of ·00047 part of its volume for every degree of the thermometer. At other temperatures its expansion is anomalous. Like ether its evaporation produces intense cold. The ultimate products of its combustion are carbonic anhydride and water. In consequence of its great hygroscopic power, when swallowed undiluted it causes death by absorbing from the tissues their combined water. It acts as a powerful antiseptic substance, and is therefore extensively employed in the preservation of animal substances. With the acids it forms ethers with the elimination of water; thus we have ethylic, hydrochloric, oxalic, formic, hydrobromic, hydriodic ether, &c. Its action on potassium is similar to that of water, potassium ethylate being formed.

In contact with spongy platinum, alcohol becomes oxidized, giving rise to aldehyd and acetic acid. If, however, the platinum be made red-hot, the spirit gradually burns away, the platinum meantime continuing to glow. Guided by these facts, Mr. GILL, some years ago, invented an alcohol lamp, which is constructed as follows:—He takes an ordinary spirit lamp, and a piece of platinum wire about $\frac{1}{100}$th of an inch thick, which he coils partly around the cotton wick of the lamp, and partly above it. The lamp then being lighted the wire is heated to redness, when the flame is extinguished. The wire, however, continues red hot as long as any spirit remains in the lamp. It affords sufficient light to show the face of a watch at night, and a lucifer match can be ignited when applied to the glowing wire with less trouble than in the ordinary way. It is said not to consume more than $\frac{3}{4}$ oz. of methylated spirit in twelve hours.

The percentage composition of alcohol is, according to Dumas and Boullay, as follows:—

Carbon	52·37
Hydrogen	13·01
Oxygen	34·61
	99·99

This represents 2 equivalents of carbon, 6 eq. of hydrogen, and 1 of oxygen, or C_2H_6O. It may be viewed as a hydrate of ethyl ($C_2H_5.HO$), or as an atom of water in which half the hydrogen is replaced by the radicle ethyl, thus—

$$\left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} O$$

When regarded as a product of the decomposition of grape sugar, under the influence of an organic nitrogenous ferment, its formation may be explained thus:— $C_6H_{12}O_6 + H_2O = (C_2H_6O)_2$ (alcohol), $+ 2CO_2$, carbonic anhy-

dride + H_2O, water. Grape sugar alone yields alcohol; cane sugar, before it undergoes the vinous fermentation, being first converted into this substance by contact with the ferment. When passed through a red-hot tube alcohol is decomposed, giving rise, amongst other products, to hydrogen, marsh gas, olefiant gas, naphthalin, benzol, carbonic oxide, and carbonic anhydride.

Purity.—The presence of water in alcohol is shown by the specific gravity, and may be estimated by the alcoholometric process described further on; water may also be detected by white anhydrous sulphate of copper turning blue when dropped into it. The absence of other foreign matters by the following tests:—

1. Its colour and transparency are not affected by the addition of a little colourless oil of vitriol, or by a solution of nitrate of silver, and subsequent exposure for some time to solar light, unless essential oil or organic matter be present, when the alcohol assumes a reddish tinge. 2. It should be neutral to test-paper, colourless, leave no residue on evaporation, and be miscible, in all proportions, with water and with ether. 3. Its boiling-point should never be less than 170° Fahr.; a lower temperature suggests the presence of wood spirit, or acetone, or one of the ethers. To detect wood spirit or wood naphtha, a modification of Nessler's test is used. A dilute solution of the iodides employed in making Nessler's solution in pure alcohol is formed, in the proportion of 2 or 3 grams of the salts to 100 c.c. of alcohol. About 4 c.c. of the suspected alcohol are taken, to which are added 2 or 3 drops of the test solution, a few drops of alcoholic ammonia, and, lastly, a little alcoholic potash; if wood spirit be present, the solution will remain clear, but if the alcohol be pure, the characteristic reddish-brown precipitate will appear. The precipitate is soluble in acetone, which is always present in wood spirit.

Tests.—1. Alcohol may generally be recognized by its volatility, inflammability, odour, taste, miscibility with water, power of dissolving camphor and resins, and other qualities already described. 2. If a few fibres of asbestos be moistened with a saturated solution of bichromate of potash in oil of vitriol, and exposed to the smallest possible portion of hot alcohol vapour, it is almost instantly turned green, owing to the formation of oxide of chromium. In practice, the asbestos may be inserted in the neck of a retort, or even of a bulbed glass-tube containing a few drops of the suspected solution, when the effect occurs as soon as distillation commences. Ether and pyroxylic spirit produce a nearly similar result; but the first of these is distinguished from alcohol by its not being miscible with water in all proportions; and the second by the Nessler's Test; whilst both may be readily distinguished by their peculiar and characteristic odour. 3. Dissolve 3 parts crystallized carbonate of soda in 10 parts water. To this solution add 1 part of liquid to be tested, and heat to about 160° Fahr. Lastly, add iodine in small pieces, till it has entirely dissolved, and the liquid has become colourless. If alcohol be present, iodoform will make its appearance on cooling, and sink to the bottom in the form of a yellow powder.* As a similar result

* A modification of this test, which is very similar to Lieben's, has been proposed by Hager:—Two solutions are required, one consisting of potassic iodide dissolved in five or six times its weight of water, supersaturated with iodine; the other of a 10 per cent. solution of caustic potash. The clear liquid under examination is heated to about 50° Cent. with 5 or 6 drops of the potash solution, and the iodine solution is then added, with gentle agitation, till the liquid becomes of a yellowish brown colour. If upon agitating the liquid this colour does not disappear, a drop or more of the potash solution is added with a glass rod till complete decoloration takes place. The resulting iodoform then falls to the bottom of the test-tube in yellow crystals.

is obtained with wood spirit, this must be proved to be absent before applying this test.

A reliable method of proving that a sample is ethylic alcohol is the production of ethylic ether, by acting on the suspected liquid with sulphuric acid.

In Cases of Death.—1. Alcohol may be detected by the odour of the contents of the stomach and ejected matter, and by their ready inflammability. 2. The spirit may be separated by digestion with water, filtration, the addition of carbonate of potash, and distillation.

Uses.—Alcohol is used by the varnish-maker to dissolve resins; by the perfumer, to extract the odours of plants, and to dissolve essential oils, soaps, and other similar bodies; by the pharmacist, to prepare tinctures and other medicinal substances; by the philosophical instrument-maker, to fill the bulbs of thermometers required to measure extreme degrees of cold; by the photographer, in the preparation of collodion; by the chemist, in analysis, and in the manufacture of numerous preparations; and by the anatomist and naturalist, as an antiseptic. It is also frequently burnt in lamps, and in those parts of the world where it is inexpensive, it is employed in the manufacture of vinegar. Its uses, when dilute, as in the spirituous liquors of commerce, are well known. It has also been used for a multitude of other purposes.

Alcoholate. *Syn.* Alcohate.—A salt in which alcohol appears to replace the water of crystallization, as exemplified in certain chlorides and nitrates. Some of the alcoholates may be formed by simple solution and crystallization of the salt in alcohol. They are very unstable, being readily decomposed by water.

Methylated Spirit.—Spirit of wine of not less sp. gr. than 0·890, to which one-tenth of its volume of purified wood naphtha has been added, the object of such addition

being that of rendering the mixture unpotable through its offensive odour and taste. The purification of this mixed spirit, or the separation of the two alcohols, though often attempted has never been accomplished. Owing to the low boiling point of methylic alcohol, it might be supposed that simple distillation would effect its separation; but when subjected to distillation both spirits come over simultaneously.

Methylated spirit, being sold duty free, can be employed by the chemical manufacturer as a solvent in many processes for which, from its much greater cost, duty paid spirit would be commercially inapplicable. Its introduction has also proved a great boon to the varnish-maker, to whom, however, it is important the wood naphtha which enters into its composition should be pure, since if it be the reverse, the quality of the resulting varnish becomes impaired.

The use of methylated spirit in the preparation of tinctures, sweet spirits of nitre, ether, or any medicine for internal use, is prohibited by law.

ALCOHOLOMETRY.

In chemistry, alcoholometry is the art or process of ascertaining the richness of spirits in alcohol. When the term is used commercially it is understood to mean the determination of the quantity of spirit of a certain strength, taken as a standard, present in any given sample of spirituous or fermented liquors. In England this standard is called "proof spirit."

The great importance of being able accurately to determine the strength of spirits in the United Kingdom, on account of the high duties levied on them, has induced the

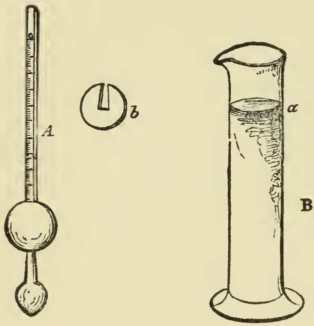
Government authorities, at various times, to investigate the subject. In 1790, the matter was referred to Sir C. Blagden, then Secretary to the Royal Society, who instituted an extensive series of experiments to determine the real specific gravities of different mixtures of alcohol and water. The results of his labours and researches were put forward, with "Gilpin's Tables," in 1794, but no practical measures appear to have been taken in consequence. In 1832 a committee of the Royal Society, at the request of the Lords of the Treasury, examined into the accuracy of the Tables, and the construction and application of the instrument (SIKES hydrometer) now used by the Revenue officers, on which they reported favourably, and declared that both were sufficiently perfect for all practical and scientific purposes. The errors introduced into calculations of the strength of spirits by these tables were found to be quite unimportant in practice, and did not, in any one instance, amount to unity in the fourth place of decimals. This method adopts the specific gravity as the test of the strength of spirits, and is founded on the fact that alcohol is considerably lighter than water, and that (with proper corrections for condensation and temperature) the specfic gravity regularly increases, or decreases, according to the relative proportions in which the two are mixed.

Several other methods of alcoholometry have been proposed, founded upon :—the variations in temperature of the vapour of alcohol of different strengths; the heat involved by its admixture with water; its dilatation by heat; the tension of its vapour; the insolubility of carbonate of potash in alcohol; its volatility, boiling point, &c. &c., the more important and useful of which are noticed further on. The method adopted by the Boards of Inland Revenue and Customs is, however, the one which is almost exclusively employed in trade and commerce in Great Britain, not only on

account of its simplicity and correctness, but for the purpose of the results exactly coinciding with the results obtained by the Revenue officers.

Methods of Alcoholometry.—I. *Methods based on the specific gravity, or percentage strength,* BY VOLUME:—1 With SIKES' *hydrometer* (Revenue System). The annexe engraving represents SIKES hydrometer, as made under the directions of the Commissioners of Inland Revenue and Customs. It consists of a spherical ball or float, with an upper and lower stem, and is made of brass, which, in the more expensive instrument, is usually coated with gold, to prevent corrosion from damp, and the acidity so generally present in spirituous liquors. The upper stem (A) is about four inches long, and is divided into ten parts, each of which contains five subdivisions. There are nine movable weights of the form *b*, of different sizes, numbered respectively 10, 20, 30, &c., to 90, each of which represents so many of the principal divisions of the stem, as its number indicates. In use, one of these weights is slipped on the lower stem; and thus, by means of them, the instrument acquires a range of above 500 divisions, or degrees, extending from the Revenue "standard alcohol" (sp. gr. ·825) to water. It is so formed a to give the specific gravity with almost perfect accuracy, at 60° Fahr. When loaded with the weight 60 it sinks in proof spirit to the line marked "P" (not shown in the engraving) on the narrow edge of the stem at 51° Fahr.; and by further placing the square weight or cap, supplied with the instru-

FIG. 3.



ment, but not shown in the plate, on the top of the upper stem, it floats exactly at the same point in distilled water. This weight or cap is found to weigh 43·66 grs., which is practically 1-12th of the total observed weight of the instrument, and its poise 60, and hence shows the difference between the gravity of proof spirit and water as explained hereafter.

The whole is fitted up in a neat mahogany case, accompanied with a thermometer, and a book of tables containing corrections for temperature, &c. When used, the glass tube, figure *B*, is filled to about the mark (*a*) with the sample for examination; the thermometer is then placed in the liquid, and stirred about for two or three minutes (observing the precaution not to breathe upon the glass, nor hold it in the hand) and the temperature noted. The hydrometer is next immersed in a similar manner, and gently pressed down in the liquor to the 0 on the stem with the finger; it having been previously loaded with any one of the nine weights that will cause it to float on the surface of the spirit at some point on the graduated part of the scale. The indication at the point cut by the surface of the liquid, as seen from below, added to the number of the weight with which the float is loaded, gives a number which must be sought in the book of Tables, which is always sold with the instrument. In this book, at the page headed "Temperature as observed by the Thermometer," and against the part of the column appropriated to the given indication (weight), will be found the strength per cent., expressed in degrees over or under proof, by volume, in whole numbers or decimal parts.

The accompanying sheet, extracted from the Tables in question, will illustrate our meaning:—

Table I.

61° TEMPERATURE.									
°		Wt. 10		Wt. 20		Wt. 30		Wt. 40	
0·0	66·8	10·0	58·0	20·0	48·4	30·0	37·7	40·0	25·7
·2	66·6	·2	57·8	·2	48·2	·2	37·5	·2	25·5
·4	66·4	·4	57·6	·4	48·0	·4	37·3	·4	25·2
·6	66·3	·6	57·5	·6	47·8	·6	37·0	·6	25·0
·8	66·1	·8	57·3	·8	47·6	·8	36·8	·8	24·7
1·0	65·9	11·0	57·1	21·0	47·3	31·0	36·6	41·0	24·5
·2	65·7	·2	56·9	·2	47·2	·2	36·4	·2	24·2
·4	65·6	·4	56·7	·4	47·0	·4	36·1	·4	24·0
·6	65·4	·6	56·6	·6	46·8	·6	35·9	·6	23·7
·8	65·3	·8	56·4	·8	46·6	·8	35·6	·8	23·5
2·0	65·1	12·0	56·2	22·0	46·4	32·0	35·4	42·0	23·2
·2	64·9	·2	56·0	·2	46·2	·2	35·2	·2	22·9
·4	64·7	·4	55·8	·4	46·0	·4	34·9	·4	22·7
·6	64·6	·6	55·7	·6	45·8	·6	34·7	·6	22·4
·8	64·4	·8	55·5	·8	45·6	·8	34·4	·8	22·2
3·0	64·2	13·0	55·3	23·0	45·4	33·0	34·2	43·0	21·9
·2	64·0	·2	55·1	·2	45·2	·2	34·0	·2	21·6
·4	63·9	·4	54·9	·4	45·0	·4	33·8	·4	21·4
·6	63·7	·6	54·7	·6	44·7	·6	33·5	·6	21·1
·8	63·6	·8	54·5	·8	44·5	·8	33·3	·8	20·9
4·0	63·4	14·0	54·3	24·0	44·3	34·0	33·1	44·0	20·6
·2	63·2	·2	54·1	·2	44·1	·2	32·9	·2	20·3
·4	63·0	·4	53·9	·4	43·9	·4	32·6	·4	20·1
·6	62·9	·6	53·8	·6	43·6	·6	32·4	·6	19·8
·8	62·7	·8	53·6	·8	43·4	·8	32·1	·8	19·6
5·0	62·5	15·0	53·4	25·0	43·2	35·0	31·9	45·0	19·3
·2	62·3	·2	53·2	·2	43·0	·2	31·7	·2	19·0
·4	62·1	·4	53·0	·4	42·8	·4	31·4	·4	18·8
·6	62·0	·6	52·8	·6	42·5	·6	31·2	·6	18·5
·8	61·8	·8	52·6	·8	42·3	·8	30·9	·8	18·3
6·0	61·6	16·0	52·4	26·0	42·1	36·0	30·7	46·0	18·0
·2	61·4	·2	52·2	·2	41·9	·2	30·4	·2	17·7
·4	61·2	·4	52·0	·4	41·7	·4	30·2	·4	17·4
·6	61·1	·6	51·8	·6	41·4	·6	29·9	·6	17·2
·8	60·9	·8	51·6	·8	41·2	·8	29·7	·8	16·9
7·0	60·7	17·0	51·4	27·0	41·0	37·0	29·4	47·0	16·6
·2	60·5	·2	51·2	·2	40·8	·2	29·2	·2	16·3
·4	60·3	·4	51·0	·4	40·6	·4	28·9	·4	16·0
·6	60·2	·6	50·8	·6	40·3	·6	28·7	·6	15·8
·8	60·0	·8	50·6	·8	40·1	·8	28·4	·8	15·5
8·0	59·8	18·0	50·4	28·0	40·0	38·0	28·2	48·0	15·2
·2	59·6	·2	50·2	·2	39·7	·2	28·0	·2	14·9
·4	59·4	·4	50·0	·4	39·5	·4	27·7	·4	14·7
·6	59·3	·6	49·8	·6	39·2	·6	27·5	·6	14·4
·8	59·1	·8	49·6	·8	39·0	·8	27·2	·8	14·2
9·0	58·9	19·0	49·4	29·0	38·8	39·0	27·0	49·0	13·9
·2	58·7	·2	49·2	·2	38·6	·2	26·7	·2	13·6
·4	58·5	·4	49·0	·4	38·4	·4	26·5	·4	13·3
·6	58·4	·6	48·8	·6	38·1	·6	26·2	·6	13·1
·8	58·2	·8	48·6	·8	37·9	·8	26·0	·8	12·8
	58·0	20·0	48·4	30·0	37·7	40·0	25·7	50·0	12·5

Over Proof.

In reading off the indication, to ensure accuracy, it is necessary to allow for the convexity of the liquid at the part where it immediately rests against the stem. In an instrument requiring so much care and skill in its manufacture, the purchaser should be careful to procure a perfect one. A very slight blow, friction from continual wiping with a rough cloth, and other apparently trivial causes, tend to injure so delicate an instrument. The shape of the weights occasionally varies; some being intended to be attached to the hydrometer at the bottom of the spindle, and others to rest on its top. The first is, perhaps, the better plan, since it tends to make the instrument float with greater steadiness in the liquid; but, at the same time, it renders its adjustment by the maker a matter of greater difficulty.

In employing this instrument, the Revenue officers are instructed to take the nearest degree above the surface of the mercury, when its stands between any two degrees of the thermometer; and the division on the scale of the hydrometer next below the surface of the liquid, when it cuts the stem between any two lines; thus giving the difference in favour of the trader in both cases.

By means of the table on the next page, the hydrometer indication, or the degrees over or under proof, of the Revenue system, may be converted into real specific gravities, by mere inspection; and the corresponding per-centage richness in alcohol of any sample may be found, either by weight or volume.

The specific gravities in this table are such as, on being referred to Gilpin's Tables, will give the expressions of proof strength answering to the whole indications of the Revenue hydrometer. Intermediate values at fifths of indications may be had by taking proportional differences between the nearest tabular numbers. Thus, to find the specific gravity

TABLE II.—*Showing the Densities and Values of Spirits at 60° Fahr., corresponding to every Indication of* SIKES' *Hydrometer.*

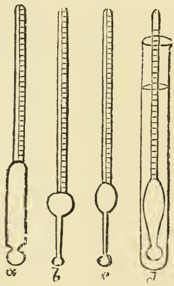
Sikes' Hydrometer Indication.	Strength per cent.	Specific Gravity.	Per cents. of Absol. Alcohol. By Measure.	Per cents. of Absol. Alcohol. By Weight.	Sikes' Hydrometer Indication.	Strength per cent.	Specific Gravity.	Per cents. of Absol. Alcohol. By Measure.	Per cents. of Absol. Alcohol. By Weight.
	O.P.					O.P.			
0	67·0	·81520	95·28	92·78	51	11·4	·90551	63·54	55·70
1	66·1	·81715	94·78	92·08	52	10·0	·90732	62·74	54·89
2	65·3	·81889	94·31	91·42	53	8·6	·90913	61·94	54·09
3	64·5	·82061	93·84	90·78	54	7·1	·91107	61·09	53·23
4	63·6	·82251	93·33	90·07	55	5·6	·91299	60·24	52·38
5	62·7	·82441	92·80	89·36	56	4·2	·91479	59·43	51·57
6	61·8	·82622	92·29	88·67	57	2·7	·91666	58·58	50·73
7	60·9	·82800	91·77	87·99	58	1·3	·91839	57·78	49·94
8	60·0	·82978	91·25	87·30		U.P			
9	59·1	·83151	90·74	86·63	59	0·3	·92037	56·86	49·04
10	58·2	·83323	90·23	85·96	60	1·9	·92228	55·96	48·17
11	57·3	·83494	89·72	85·30	61	3·4	·92408	55·10	47·33
12	56·4	·83661	89·21	84·65	62	5·0	·92597	54·19	46·46
13	55·5	·83827	88·70	84·00	63	6·7	·92798	53·22	45·53
14	54·6	·83993	88·17	83·33	64	8·3	·92984	52·30	44·65
15	53·7	·84153	87·67	82·70	65	10·0	·93176	51·36	43·76
16	52·7	·84331	87·10	81·99	66	11·7	·93367	50·39	42·84
17	51·7	·84509	86·51	81·26	67	13·5	·93586	49·34	41·86
18	50·7	·84680	85·95	80·58	68	15·3	·93758	48·31	40·90
19	49·7	·84851	85·39	79·89	69	17·1	·93949	47·29	39·96
20	48·7	·85022	84·81	79·19	70	18·9	·94135	46·29	39·04
21	47·6	·85205	84·19	78·44	71	20·8	·94327	45·20	38·04
22	46·6	·85372	83·61	77·74	72	22·7	·94518	44·09	37·03
23	45·6	·85537	83·04	77·07	73	24·7	·94709	42·96	36·01
24	44·6	·85700	82·47	76·39	74	26·7	·94899	41·82	34·98
25	43·5	·85878	81·85	75·66	75	28·8	·95092	40·63	33·92
26	42·4	·86055	81·21	74·92	76	31·0	·95288	39·40	32·82
27	41·3	·86229	80·59	74·19	77	33·2	·95484	38·10	31·68
28	40·2	·86402	79·97	73·47	78	35·6	·95677	36·76	30·50
29	39·1	·86574	79·34	72·75	79	38·1	·95877	35·32	29·24
30	38·0	·86745	78·71	72·03	80	40·6	·96068	33·90	28·01
31	36·9	·86915	78·08	71·32	81	43·3	·96259	32·41	26·73
32	35·7	·87099	77·40	70·54	82	46·1	·96457	30·77	25·32
33	34·5	·87282	76·71	69·77	83	49·1	·96651	29·08	23·88
34	33·4	·87450	76·08	69·06	84	52·2	·96846	27·31	22·38
35	32·2	·87627	75·41	68·32	85	55·5	·97049	25·39	20·77
36	31·0	·87809	74·72	67·55	86	59·0	·97254	23·41	19·11
37	29·8	·87988	74·03	66·79	87	62·5	·97458	21·39	17·42
38	28·5	·88179	73·29	65·98	88	66·0	·97660	19·41	15·78
39	27·3	·88355	72·60	65·23	89	69·4	·97857	17·46	14·16
40	26·0	·88544	71·86	64·43	90	72·8	·98057	15·51	12·56
41	24·8	·88716	71·17	63·68	91	76·1	·98261	13·58	10·97
42	23·5	·88901	70·43	62·89	92	79·2	·98452	11·85	9·56
43	22·2	·89086	69·69	62·10	93	82·3	·98657	10·04	8·08
44	20·9	·89268	68·95	61·32	94	85·2	·98866	8·28	6·65
45	19·6	·89451	68·21	60·53	95	88·0	·99047	6·83	5·48
46	18·3	·89629	67·47	59·76	96	90·7	·99251	5·25	4·20
47	16·9	·89822	66·67	58·92	97	93·3	·99448	3·80	3·03
48	15·6	·89997	65·93	58·15	98	95·9	·99658	2·31	1·84
49	14·2	·90182	65·14	57·34	99	98·2	·99851	·997	·793
50	12·8	·90367	64·34	56·52	100	...	1·00000	...	...

This Table has been copied, by permission from Loftus's "Inland Revenue Officer's Report."

that should stand opposite to Indication 70·6, we first obtain the difference between the densities standing in a line with Indications 70 and 71 respectively, and then say as 1 : 0·6 : : ·00192 : ·00115, and ·94135 + ·00115 = ·94250, the specific gravity required.

2. *With Glass Alcoholometers.* The alcoholometers of TRALLES, and most others of a like description made in England, give the percentage strength, by volume, with tolerable accuracy, at the standard temperature of 60° Fahr. Alcoholometers are simply hydrometers adapted to the densities of alcohol, either concentrated or dilute. Some of these, as BAUMÉ'S, CARTIER'S, &c., merely indicate the number of degrees corresponding to the state of concentration of the liquid. Others, of a similar construction, as those of RICHTER (*a*), TRALLES (*b*), and GAY-LUSSAC (*c*), have their stems so graduated as at once to indicate the proportion per cent. of alcohol present, either by weight, or by volume, at some standard temperature. By TRALLES' the volumetric percentage of alcohol is ascertained from the portion of stem immersed in the liquid. In GAY-LUSSAC'S the stem of

FIG. 4.



the instrument is divided into 100 divisions, each of which is equal to 1 per cent. of alcohol, by volume, at 59° Fahr.; the hundredth division indicates pure or absolute alcohol, whilst 0 or zero corresponds with distilled water. DICAS' hydrometer is made of copper, the weights used as poises are of brass, and are placed on the pointed summit of the stem. The strength of the spirit is indicated by a certain number above or below proof. This instrument is used chiefly in America. A third class, as those of the Abbé BROSSARD-VIDAL, FIELD, &c., are essentially thermometers, with scales

which indicate the boiling points of spirits of different strengths, instead of the common thermometric degrees; whilst to a fourth class belongs the alcoholometer of M. Silbermann, which is based upon the known rate of expansion of alcoholic liquids by heat, expressed in alcoholometric degrees; and that of M. Geissler, which depends on the measurement of the tension of the vapour of the liquid, as indicated by the height to which it raises a small column of mercury. In Sikes' hydrometer, as already explained, used by officers of the Revenue, the scale of the instrument is enormously extended by the use of movable weights, with each of which it becomes, in fact, a separate instrument, adapted to a certain range of specific gravities.

d is a very convenient alcoholometer for ordinary purposes. It is of the usual form, but its stem on one side exhibits the percentage richness of the sample in alcohol by volume; and on the other, the percentage by weight. Thus, both results may be obtained at one trial. This instrument is sometimes called Richter's in England. A further improvement is a modification of Sikes' hydrometer, which carries a small spirit-thermometer in the bulb, to which a scale is fixed ranging from 35° to 82° Fahr. The stem of the instrument is divided into 100 degrees. When it is used the particular degree cut by the surface of the liquid to be examined, as well as the temperature indicated by the thermometer, are noted, and with these data, reference being made to the tables accompanying the instrument, the content of spirit over or under proof is at once seen. The instrument is made of glass.

Lovi's Beads are small hollow spheres of glass carefully adjusted and numbered, in sets, intended to supersede the hydrometer in determining the density of fluids. They are used by dropping them into the liquid, in succession, until one is found that exhibits indifference as to buoyancy, and will float under the surface at any

point at which it may be placed. The number on the ball indicates, in thousandths, the specific gravity sought. They are particularly serviceable in the hurry of the commercial laboratory, and have the advantage of being applicable to very small quantities of liquid; but their use, of course, requires the same precautions, and the results obtained, the same corrections for deviations from the normal temperature, as with other instruments.

3. *From the specific gravity.* The temperature having been taken by a thermometer, and the specific gravity ascertained by any of the usual methods, but preferably by means of an accurate glass hydrometer, it merely becomes necessary to refer to Table II., where, against the number expressing the specific gravity, the alcoholic content per cent., by volume, of the sample examined, will be found for 60° Fahr., subject to the corrections just referred to, when the temperature is either above or below this point.

If the precise specific gravity sought cannot be found in the Table, the difference between it and the next greater specific gravity must be taken for the numerator of a fraction, having for its denominator the difference between the greater and the next less specific gravity in the Table. This fraction, added to the percentage of alcohol in the fourth column of the table, opposite the greater specific gravity, will give the true percentage sought. Thus, the sp. gr. ·96051 is not in the Table, and the next greater number is ·96068; the former must, therefore, be deducted from the latter, and the difference (17) put as the numerator of the fraction, having for its denominator 191, the difference between ·96068 and ·95877. The fraction ($\frac{17}{191}$) ·089, so found, added to the percentage strength opposite ·96068 in the third column, gives 33·989 as the true percentage of alcohol in the given sample.

In view of the probability that the liquid at the time of its being examined would have a temperature differing from

the above—viz., 60° Fahr.—and in order to do away with the necessity of bringing it to that point, TRALLES constructed the following Table, by which to ascertain, from the specific gravity at the indicated temperature, the quantity of absolute alcohol in a liquid, expressed in volume in percentages:—

TABLE III.

Per cent. of alcohol by volume.	Specific Gravity of the Liquid ascertained by Glass Instruments, at the indicated Temperature.											
	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°
0	·9994	·9997	·9997	·9998	·9997	·9994	·9991	·9987	·9981	·9976	·9970	·9962
5	·9924	·9926	·9926	·9925	·9925	·9922	·9919	·9915	·9909	·9903	·9897	·9889
10	·9868	·9869	·9868	·9867	·9865	·9861	·9857	·9852	·9845	·9839	·9831	·9823
15	·9823	·9822	·9820	·9817	·9813	·9807	·9802	·9796	·9788	·9779	·9771	·9761
20	·9786	·9782	·9777	·9772	·9766	·9759	·9751	·9743	·9733	·9723	·9713	·9701
25	·9752	·9745	·9737	·9729	·9720	·9709	·9700	·9690	·9678	·9666	·9653	·9640
30	·9715	·9705	·9694	·9683	·9671	·9658	·9646	·9633	·9619	·9605	·9590	·9574
35	·9668	·9655	·9641	·9627	·9612	·9598	·9583	·9567	·9551	·9535	·9518	·9500
40	·9609	·9594	·9577	·9560	·9544	·9527	·9510	·9493	·9474	·9456	·9438	·9419
45	·9535	·9518	·9500	·9482	·9464	·9445	·9427	·9408	·9388	·9369	·9359	·9329
50	·9449	·9431	·9413	·9393	·9374	·9354	·9335	·9315	·9294	·9274	·9253	·9232
55	·9354	·9335	·9316	·9295	·9275	·9254	·9234	·9213	·9192	·9171	·9250	·9128
60	·9249	·9230	·9210	·9189	·9168	·9147	·9126	·9105	·9083	·9061	·9039	·9016
65	·9140	·9120	·9099	·9078	·9056	·9034	·9013	·8992	·8969	·8947	·8924	·8901
70	·9021	·9001	·8980	·8958	·8936	·8913	·8892	·8870	·8847	·8825	·8801	·8778
75	·8896	·8875	·8854	·8832	·8810	·8787	·8765	·8743	·8720	·8697	·8673	·8649
80	·8764	·8743	·8721	·8699	·8676	·8653	·8631	·8609	·8585	·8562	·8538	·8514
85	·8623	·8601	·8579	·8556	·8533	·8510	·8488	·8465	·8441	·8418	·8394	·8370
90	·8469	·8446	·8423	·8401	·8379	·8355	·8332	·8309	·8285	·8262	·8238	·8214

To ascertain the alcoholic content in a spirituous liquid, the sp. gr. and temperature of which are not included in the above Table, proceed as follows:—Suppose the liquid has a sp. gr. of ·9500, and its temperature is 67° Fahr. First look down the temperature column marked "65°" for a number next higher than ·9500: this will be ·9567; then down the temperature column marked "70°" for the gravity nearest to the given gravity: this will be ·9551. By next subtracting ·9500 from the numbers ·9567 and ·9551 respectively, we obtain the numbers ·0067 and ·0051; and these again subtracted from each other give us ·0016, which is the difference in sp. gr. for 5° of temperature Fahr. We next divide ·0016 by 5, which gives us ·00032, or the difference for one degree of temperature. and as our liquid has a

temperature of 67° Fahr., or 2° above 65°, we multiply ·00032 by 2, and thus obtain ·00064, which, being added to ·9500, gives us ·95064, as the sp. gr. of our liquid at 65° Fahr. "The alcohol by volume" corresponding with the sp. gr. ·9567 at 65° will be seen in the Table to be 35 per cent., whilst at ·9493 it is shown to be 40 per cent. By deducting ·9493 from ·9567 we obtain the number ·0074, which it will be seen is the variation in the sp. gr. corresponding with 5 per cent. of alcohol.

If, therefore, ·0074 denotes 5 per cent. of alcohol, ·00606 (the difference in gravity between ·9567 and ·95064) is approximately equivalent to $4\frac{1}{10}$th per cent.; and this added to 35 per cent. (the alcohol in the liquid having the gravity ·9567) will give $38\frac{1}{10}$th by volume as the percentage of a spirituous liquid having the sp. gr. ·950 at 67° Fahr.

Gay-Lussac's alcoholometer, which closely resembles that of Tralles, is adjusted for the temperature of 59° Fahr., or 15° Ct., water being taken as unity. In practice the difference between this standard and that of Tralles (viz., 60° Fahr.) is so slight that the results obtained by each may be regarded as concordant.

Gay-Lussac arranged a table which, although not so strictly accurate as that of Tralles previously given, enables the volumetric percentage of alcohol in a liquid to be easily ascertained from the observed percentage as indicated by the alcoholometer at the same temperature. Thus suppose the alcoholometer marks 20 per cent. at 60·8° Fahr. The observed 20 per cent. must be sought in the horizontal column at the top of the Table, and in the vertical column below it, the eye must be carried down until it meets with a number standing in the same horizontal column as the observed temperature—viz., "60·8°" in the left-hand column This will be found to be 19·7. The liquid, therefore, at the observed temperature 60·8 Fahr., contains 19·7 per cent. of anhydrous alcohol.

TABLE IV.—*To find directly the Percentage of Absolute Alcohol of a Liquid at any Temperature, from the observed Percentage at the same Temperature.*

Temperature. Fahr.	Cent.	Observed Percentage of the Alcoholometer. 1 p. ct.	2 p. ct.	3 p. ct.	4 p. ct.	5 p. ct.	6 p. ct.	7 p. ct.	8 p. ct.	9 p. ct.	10 p. ct.	11 p. ct.	12 p. ct.	13 p. ct.	14 p. ct.	15 p. ct.	16 p. ct.	17 p. ct.	18 p. ct.	19 p. ct.	20 p. ct.
32·0	0	1·3	2·4	3·4	4·4	5·4	6·5	7·5	8·6	9·7	10·9	12·2	13·4	14·7	16·1	17·5	19·0	20·4	21·7	23·0	24·3
33·8	1	—	—	—	—	—	—	—	—	—	—	—	13·4	14·7	16·0	17·3	18·7	20·1	21·4	22·7	24·0
35·6	2	—	—	—	—	—	—	—	—	—	—	—	13·4	14·7	16·0	17·2	18·6	19·9	21·2	22·4	23·7
37·4	3	—	—	—	—	—	—	—	—	—	—	—	13·3	14·6	15·9	17·1	18·3	19·7	20·9	22·1	23·4
39·2	4	—	—	—	—	—	—	—	—	—	—	—	13·3	14·5	15·8	16·9	18·1	19·4	20·7	21·9	23·1
41·0	5	1·4	2·5	3·5	4·5	5·5	6·6	7·7	8·7	9·8	10·9	12·1	13·2	14·4	15·7	16·8	18·0	19·2	20·5	21·6	22·8
42 8	6	—	—	—	—	—	—	—	—	—	—	—	13·1	14·3	15·6	16·7	17·8	19·0	20·3	21·4	22·5
44·6	7	—	—	—	—	—	—	—	—	—	—	—	13·0	14·2	15·4	16·6	17·7	18·8	20·0	21·0	22·1
46·4	8	—	—	—	—	—	—	—	—	—	—	—	13·0	14·1	15·3	16·4	17·5	18·6	19·7	20·7	21·8
48·2	9	—	—	—	—	—	—	—	—	—	—	—	12·9	14 0	15·1	16·2	17·3	18·4	19·5	20·5	21·6
50·0	10	1·4	2·4	3·4	4·5	5·5	6·5	7·5	8·5	9·5	10·6	11·7	12·7	13·8	14·9	16·0	17·0	18·1	19·2	20·2	21·3
51·8	11	1·3	2·4	3·4	4·4	5·4	6·4	7·4	8·4	9·4	10·5	11·6	12·6	13·6	14·7	15·8	16·8	17·9	19·0	20·0	21·0
53·6	12	1·2	2·3	3·3	4·3	5·3	6·3	7·3	8·3	9·3	10·4	11·5	12·5	13·5	14·6	15·6	16·6	17·6	18·7	19·7	20·7
55·4	13	1·2	2·2	3·2	4·2	5·2	6 2	7·2	8·2	9·2	10·3	11·4	12·4	13·4	14·4	15·4	16·4	17·4	18·5	19·5	20·5
57·2	14	1·1	2·1	3·1	4·1	5·1	6·1	7·1	8·1	9·1	10·2	11·2	12·2	13·2	14·2	15·2	16·2	17·2	18·2	19·2	20·2
59·0	15	1·0	2·0	3·0	4·0	5·0	6·0	7·0	8·0	9·0	10·0	11·0	12·0	13·0	14·0	15·0	16·0	17·0	18·0	19 0	20·0
60·8	16	0·9	1·9	2·9	3·9	4·9	5·9	6·9	7·9	8·9	9·9	10·9	11·9	12·9	13·9	14·9	15·9	16·9	17·8	18·7	19·7
62·6	17	0.8	1·8	2·8	3·8	4·8	5·8	6·8	7·8	8·8	9·8	10·8	11·7	12·7	13·7	14·7	15·6	16·6	17·5	18·4	19·4
64·4	18	0·7	1·7	2·7	3·7	4·7	5·7	6·7	7·7	8·7	9·7	10·7	11·6	12·5	13·5	14·5	15·4	16·3	17·3	18·2	19·1
66·2	19	0·6	1·6	2·6	3·6	4·5	5·5	6·5	7·5	8·5	9·5	10·5	11·4	12·4	13·3	14·3	15·2	16·1	17·0	17·9	18·8
68·0	20	0·5	1·5	2·4	3·4	4·4	5·4	6·4	7·3	8·3	9·3	10·3	11·2	12·2	13·1	14·0	14·9	15·8	16·7	17·6	18·5
69·8	21	0·4	1·4	2·3	3·3	4·3	5·2	6·2	7·1	8·1	9·1	10·1	11·0	11·9	12·8	13·7	14·6	15·5	16·4	17·3	18·2
71·6	22	0·3	1·3	2·2	3·2	4·1	5·1	6·1	7·0	7·9	8·9	9·9	10·8	11·7	12·6	13·5	14·4	15·3	16·2	17·0	17·9
73·4	23	0·1	1·1	2·1	3·1	4·0	4·9	5·9	6·8	7·8	8·7	9·7	10·6	11·5	12·4	13·3	14·1	15·0	15·9	16·7	17·6
75·2	24	0·0	1·0	1·9	2·9	3·8	4·8	5·8	6·7	7·6	8·5	9·5	10·4	11·3	12·2	13·1	13·9	14·8	15·7	16·5	17·4
77·0	25	—	0·8	1·7	2·7	3·6	4·6	5·5	6·5	7·4	8·3	9·3	10·2	11·1	12·0	12·8	13·6	14·5	15·4	16·2	17·1
78·8	26	—	0·7	1·6	2·6	3·5	4·4	5·4	6·3	7·2	8·1	9·0	9·9	10·8	11·7	12·6	13·4	14·2	15·1	15·9	16·7
80·6	27	—	0·5	1·5	2·4	3·3	4·3	5·2	6·1	7·0	7·9	8·8	9·7	10·6	11·5	12·3	13·1	13·9	14·8	15·6	16·4
82·4	28	—	0·3	1·3	2·2	3·1	4·1	5·0	5·9	6·8	7·7	8·6	9·5	10·3	11·2	12·0	12·8	13·6	14·4	15·2	16 0
84·2	29	—	0·1	1·1	2·0	2·9	3·9	4·8	5·7	6·6	7·5	8·4	9·2	10·1	11·0	11·7	12·5	13·3	14·1	14·9	15·7
86·0	30	—	0·0	0·9	1 9	2·8	3·7	4·6	5·5	6·4	7·3	8·1	9·0	9·8	10·7	11·5	12·3	13·0	13·8	14·6	15·4

TABLE IV.—*continued.*

Temperature. Fahr.	Cent.	Observed Percentage of the Alcoholometer. 21 p. ct.	22 p. ct.	23 p. ct.	24 p. ct.	25 p. ct.	26 p. ct.	27 p. ct.	28 p. ct.	29 p. ct.	30 p. ct.	31 p. ct.	32 p. ct.	33 p. ct.	34 p. ct.	35 p. ct.	36 p. ct.	37 p. ct.	38 p. ct.	39 p. ct.	40 p. ct.
32.0	0	25.7	27.1	28.5	29.9	31.1	32.3	33.4	34.5	35.6	36.6	37.6	38.5	39.6	40.6	41.5	42.5	43.5	44.4	45.4	46.4
33.8	1	25.4	26.8	28.1	29.4	30.6	31.8	32.9	34.0	35.1	36.1	37.1	38.1	39.1	40.1	41.2	42.2	43.1	44.1	45.0	46.0
35.6	2	25.0	26.4	27.6	28.9	30.2	31.4	32.5	33.5	34.6	35.6	36.7	37.7	38.7	39.7	40.7	41.7	42.7	43.7	44.6	45.5
37.4	3	24.7	26.0	27.3	28.6	29.8	31.0	32.1	33.1	34.1	35.2	36.2	37.3	38.3	39.3	40.3	41.3	42.3	43.2	44.2	45.2
39.2	4	24.4	25.7	26.9	28.1	29.3	30.6	31.6	32.7	33.7	34.7	35.7	36.7	37.7	38.8	39.8	40.8	41.8	42.8	43.8	44.8
41.0	5	24.1	25.3	26.5	27.7	28.9	30.1	31.2	32.3	33.3	34.3	35.3	36.3	37.3	38.3	39.3	40.3	41.4	42.4	43.4	44.4
42.8	6	23.7	25.0	26.1	27.3	28.5	29.7	30.8	31.8	32.8	33.8	34.9	35.9	36.9	37.9	38.9	39.9	40.9	41.9	42.9	43.9
44.6	7	23.4	24.7	25.8	27.0	28.1	29.3	30.3	31.3	32.3	33.3	34.3	35.4	36.4	37.4	38.4	39.4	40.4	41.4	42.4	43.4
46.4	8	23.0	24.2	25.4	26.6	27.7	28.9	29.9	30.9	31.9	32.9	33.9	34.9	35.9	36.9	38.0	39.0	40.0	41.0	42.0	43.0
48.2	9	22.7	23.9	25.0	26.2	27.3	28.5	29.5	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.6	39.6	40.6	41.6	42.6
50.0	10	22.4	23.5	24.6	25.8	26.9	28.0	29.1	30.1	31.1	32.1	33.1	34.1	35.1	36.1	37.1	38.1	39.1	40.1	41.1	42.1
51.8	11	22.1	23.2	24.3	25.4	26.5	27.7	28.7	29.7	30.7	31.7	32.7	33.7	34.7	35.7	36.7	37.7	38.7	39.7	40.7	41.7
53.6	12	21.8	22.9	24.0	25.1	26.1	27.2	28.2	29.2	30.2	31.2	32.2	33.2	34.3	35.3	36.3	37.3	38.3	39.3	40.3	41.3
55.4	13	21.5	22.6	23.7	24.7	25.7	26.8	27.8	28.8	29.8	30.8	31.8	32.8	33.8	34.8	35.8	36.8	37.8	38.8	39.8	40.9
57.2	14	21.2	22.3	23.3	24.3	25.3	26.4	27.4	28.4	29.4	30.4	31.4	32.4	33.4	34.4	35.4	36.4	37.4	38.4	39.4	40.4
59.0	15	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0	33.0	34.0	35.0	36.0	37.0	38.0	39.0	40.0
60.8	16	20.7	21.7	22.7	23.7	24.7	25.7	26.6	27.6	28.6	29.6	30.6	31.6	32.5	33.5	34.5	35.5	36.5	37.5	38.5	39.5
62.6	17	20.4	21.4	22.4	23.4	24.4	25.4	26.3	27.3	28.2	29.2	30.2	31.2	32.1	33.1	34.1	35.1	36.1	37.1	38.1	39.1
64.4	18	20.1	21.1	22.0	23.0	24.0	25.0	25.9	26.9	27.8	28.8	29.8	30.8	31.7	32.6	33.6	34.6	35.6	36.6	37.6	38.6
66.2	19	19.8	20.8	21.7	22.7	23.6	24.6	25.5	26.4	27.3	28.3	[illegible]	30.3	31.2	32.2	33.2	34.2	35.2	36.2	37.2	38.2
68.0	20	19.5	20.5	21.4	22.4	23.3	24.3	25.2	26.1	27.0	27.9	28.9	29.9	30.8	31.8	32.8	33.8	34.8	35.8	36.8	37.8
69.8	21	19.1	20.1	21.1	22.1	22.9	23.9	24.8	25.6	26.6	27.5	28.5	29.5	30.4	31.4	32.4	33.4	34.4	35.4	36.4	37.4
71.6	22	18.8	19.8	20.7	21.6	22.5	23.5	24.3	25.2	26.2	27.1	28.1	29.1	30.0	31.0	32.0	33.0	34.0	35.0	36.0	36.9
73.4	23	18.5	19.4	20.3	21.3	22.2	23.1	24.0	24.9	25.8	26.7	27.7	28.7	29.6	30.6	31.6	32.6	33.5	34.5	35.5	36.5
75.2	24	18.2	19.1	20.0	21.0	21.8	22.7	23.6	24.5	25.4	26.3	27.3	28.3	29.2	30.2	31.1	32.1	33.1	34.1	35.1	36.1
77.0	25	17.9	18.8	19.7	20.6	21.5	22.4	23.2	24.2	25.1	26.0	26.9	27.9	28.8	29.7	30.7	31.7	32.7	33.7	34.7	35.7
78.8	26	17.6	18.5	19.4	20.3	21.2	22.1	22.9	23.8	24.7	25.6	26.5	27.5	28.4	29.3	30.3	31.3	32.3	33.3	34.3	35.3
80.6	27	17.3	18.2	19.1	20.0	20.8	21.7	22.6	23.5	24.3	25.2	26.1	27.1	27.9	28.9	29.9	30.9	31.9	32.9	33.9	34.8
82.4	28	16.9	17.9	18.8	19.6	20.5	21.4	22.2	23.1	23.9	24.8	25.7	26.6	27.5	28.5	29.5	30.5	31.5	32.5	33.5	34.4
84.2	29	16.6	17.5	18.4	19.3	20.2	21.0	21.8	22.7	23.6	24.4	25.2	26.2	27.1	28.1	29.1	30.1	31.1	32.1	33.1	34.0
86.0	30	16.3	17.2	18.1	19.0	19.8	20.7	21.5	22.4	23.2	24.0	24.9	25.8	26.7	27.7	28.7	29.7	30.7	31.6	32.6	33.6

Table IV.—*continued.*

Temperature. Fahr.	Cent.	41 p. ct.	42 p. ct.	43 p. ct.	44 p. ct.	45 p. ct.	46 p. ct	47 p. ct.	48 p. ct.	49 p. ct.	50 p. ct.	51 p. ct.	52 p. ct.	53 p. ct.	54 p. ct.	55 p. ct.	56 p. ct.	57 p. ct.	58 p. ct.	59 p. ct.	60 p. ct.
		Observed Percentage of the Alcoholometer.																			
32·0	0	47·4	48·4	49·3	50·3	51·3	52·3	53·2	54·1	55·1	56·1	57·1	58·0	59·0	59·9	60·9	61·9	62·9	63·9	64·9	65·8
33·8	1	47·0	48·0	48·9	49·9	50·8	51·8	52·8	53·7	54·7	55·7	56·7	57·6	58·6	59·6	60·6	61·6	62·5	63·5	64·5	65·5
35·6	2	46·5	47·5	48·5	49·5	50·4	51·4	52·3	53·3	54·3	55·3	56·3	57·2	58·2	59·2	60·2	61·2	62·1	63·1	64·1	65·1
37·4	3	46·2	47·1	48·1	49·0	50·0	51·0	52·0	52·9	53·9	54·8	55·8	56·8	57·8	58·8	59·8	60·8	61·7	62·7	63·7	64·7
39·2	4	45·8	46·7	47·7	48·7	49·6	50·6	51·5	52·5	53·5	54·5	55·5	56·5	57·4	58·4	59·4	60·3	61·3	62·3	63·3	64·3
41·0	5	45·3	46·2	47·2	48·2	49·2	50·2	51·1	52·1	53·1	54·0	55·0	56·0	57·0	58·0	59·0	60·0	60·9	61·9	62·9	63·9
42·8	6	44·9	45·8	46·8	47·8	48·8	49·8	50·8	51·7	52·7	53·7	54·7	55·6	56·6	57·5	58·5	59·5	60·5	61·5	62·5	63·5
44·6	7	44·4	45·4	46·4	47·4	48·4	49·4	50·4	51·3	52·3	53·2	54·2	55·2	56·2	57·1	58·1	59·1	60·1	61·1	62·1	63·1
46·4	8	44·0	45·0	46·0	47·0	47·9	48·9	49·9	50·9	51·9	52·9	53·9	54·9	55·8	56·8	57·8	58·8	59·8	60·8	61·8	62·8
48·2	9	43·6	44·6	45·6	46·6	47·5	48·5	49·5	50·5	51·5	52·5	53·5	54·5	55·4	56·4	57·4	58·4	59·4	60·4	61·4	62·4
50·0	10	43·1	44·1	45·1	46·1	47·1	48·1	49·1	50·1	51·1	52·0	53·0	54·0	55·0	56·0	57·0	58·0	59·0	60·0	61·0	62·0
51·8	11	42·7	43·7	44·7	45·7	46·7	47·7	48·7	49·7	50·7	51·7	52·7	53·7	54·6	55·6	56·6	57·6	58·6	59·6	60·6	61·6
53·6	12	42·3	43·3	44·3	45·3	46·3	47·3	48·3	49·3	50·3	51·2	52·2	53·2	54·2	55·2	56·2	57·2	58·2	59·2	60·2	61·2
55·4	13	41·9	42·9	43·9	44·9	45·9	46·9	47·9	48·9	49·9	50·9	51·9	52·8	53·8	54·8	55·8	56·8	57·8	58·8	59·8	60·8
57·2	14	41·4	42·4	43·4	44·4	45·4	46·4	47·4	48·4	49·4	50·4	51·4	52·4	53·4	54·4	55·4	56·4	57·4	58·4	59·4	60·4
59·0	15	41·0	42·0	43·0	44·0	45·0	46·0	47·0	48·0	49·0	50·0	51·0	52·0	53·0	54·0	55·0	56·0	57·0	58·0	59·0	60·0
60·8	16	40·6	41·6	42·6	43·6	44·6	45·6	46·6	47·6	48·6	49·6	50·6	51·6	52·6	53·6	54·6	55·6	56·6	57·6	58·6	59·6
62·6	17	40·1	41·1	42·1	43·1	44·1	45·2	46·2	47·2	48·2	49·2	50·2	51·2	52·2	53·2	54·2	55·2	56·2	57·2	58·2	59·2
64·4	18	39·7	40·7	41·7	42·7	43·7	44·8	45·8	46·8	47·8	48·8	49·8	50·8	51·8	52·8	53·8	54·8	55·8	56·8	57·8	58·8
66·2	19	39·3	40·3	41·3	42·4	43·4	44·4	45·4	46·4	47·4	48·4	49·4	50·4	51·4	52·4	53·4	54·4	55·4	56·4	57·4	58·4
68·0	20	38·9	39·9	40·9	42·0	43·0	44·0	45·0	46·0	47·0	48·0	49·0	50·0	51·0	52·0	53·0	54·0	55·0	56·0	57·0	58·0
69·8	21	38·4	39·4	40·4	41·5	42·5	43·5	44·6	45·6	46·6	47·6	48·6	49·6	50·6	51·6	52·6	53·6	54·6	55·6	56·6	57·6
71·6	22	38·0	39·0	40·0	41·1	42·1	43·1	44·1	45·1	46·1	47·1	48·1	49·1	50·1	51·1	52·2	53·2	54·2	55·2	56·2	57·2
73·4	23	37·6	38·6	39·6	40·6	41·6	42·6	43·6	44·6	45·7	46·7	47·7	48·8	49·8	50·8	51·8	52·8	53·8	54·8	55·8	56·8
75·2	24	37·2	38·2	39·2	40·2	41·2	42·2	43·3	44·3	45·3	46·3	47·3	48·4	49·4	50·4	51·4	52·4	53·4	54·4	55·4	56·4
77·0	25	36·7	37·7	38·7	39·8	40·8	41·9	42·9	43·9	44·9	46·0	47·0	48·0	49·0	50·0	51·0	52·0	53·0	54·0	55·0	56·0
78·8	26	36·3	37·3	38·3	39·4	40·4	41·5	42·5	43·5	44·5	45·5	46·5	47·5	48·5	49·5	50·5	51·5	52·5	53·5	54·5	55·6
80·6	27	35·9	36·9	37·9	39·0	40·0	41·1	42·1	43·1	44·1	45·1	46·1	47·1	48·1	49·1	50·2	51·2	52·2	53·2	54·2	55·2
82·4	28	35·4	36·5	37·5	38·6	39·6	40·6	41·6	42·6	43·7	44·7	45·7	46·7	47·7	48·7	49·8	50·8	51·8	52·8	53·8	54·8
84·2	29	35·0	36·0	37·1	38·1	39·1	40·2	41·2	42·2	43·3	44·3	45·3	46·3	47·3	48·4	49·4	50·4	51·4	52·4	53·4	54·4
86·0	30	34·6	35·6	36·6	37·7	38·7	39·8	40·8	41·8	42·8	43·8	44·9	45·9	47·0	48·0	49·0	50·0	51·0	52·0	53·0	54·0

TABLE IV.—*continued.*

Temperature. Fahr.	Cent.	61 p. ct.	62 p. ct.	63 p. ct.	64 p. ct.	65 p. ct.	66 p. ct.	67 p. ct.	68 p. ct.	69 p. ct.	70 p. ct.	71 p. ct.	72 p. ct.	73 p. ct.	74 p. ct.	75 p. ct.	76 p. ct.	77 p. ct.	78 p. ct.	79 p. ct.	80 p. ct.
		Observed Percentage of the Alcoholometer.																			
32.0	0	66.8	67.8	68.8	69.8	70.8	71.7	72.7	73.7	74.7	75.7	76.6	77.6	78.6	79.6	80.6	81.6	82.6	83.6	84.5	85.5
33.8	1	66.5	67.5	68.5	69.4	70.4	71.3	72.3	73.3	74.3	75.3	76.2	77.2	78.2	79.2	80.2	81.2	82.2	83.2	84.2	85.1
35.6	2	66.1	67.1	68.1	69.1	70.1	71.0	71.9	72.9	73.9	74.9	75.9	76.9	77.9	78.9	79.9	80.9	81.9	82.9	83.8	84.7
37.4	3	65.6	66.6	67.6	68.6	69.6	70.6	71.6	72.6	73.6	74.5	75.5	76.5	77.5	78.5	79.5	80.5	81.5	82.5	83.4	84.4
39.2	4	65.3	66.3	67.3	68.3	69.3	70.2	71.2	72.2	73.2	74.1	75.1	76.1	77.1	78.1	79.1	80.1	81.1	82.1	83.0	84.0
41.0	5	64.9	65.9	66.9	67.9	68.9	69.8	70.8	71.8	72.8	73.8	74.8	75.7	76.7	77.7	78.7	79.7	80.7	81.7	82.7	83.7
42.8	6	64.5	65.5	66.5	67.5	68.5	69.5	70.5	71.5	72.5	73.4	74.4	75.3	76.3	77.3	78.3	79.3	80.3	81.3	82.3	83.3
44.6	7	64.1	65.1	66.1	67.1	68.1	69.1	70.1	71.1	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0	80.0	81.0	82.0	82.9
46.4	8	63.8	64.8	65.8	66.8	67.7	68.7	69.7	70.6	71.6	72.6	73.6	74.6	75.6	76.6	77.6	78.6	79.6	80.6	81.6	82.6
48.2	9	63.4	64.4	65.4	66.4	67.3	68.3	69.3	70.3	71.3	72.3	73.3	74.2	75.2	76.2	77.2	78.2	79.2	80.2	81.2	82.2
50.0	10	63.0	64.0	65.0	66.0	67.0	67.9	68.9	69.9	70.9	71.9	72.9	73.9	74.9	75.9	76.9	77.9	78.9	79.9	80.9	81.9
51.8	11	62.6	63.6	64.6	65.6	66.6	67.6	68.6	69.6	70.6	71.6	72.6	73.5	74.5	75.5	76.5	77.5	78.5	79.5	80.5	81.5
53.6	12	62.2	63.2	64.2	65.2	66.2	67.2	68.2	69.2	70.2	71.2	72.2	73.1	74.1	75.1	76.1	77.1	78.1	79.1	80.1	81.1
55.4	13	61.8	62.8	63.8	64.8	65.8	66.8	67.8	68.8	69.8	70.8	71.8	72.8	73.8	74.8	75.8	76.8	77.8	78.8	79.8	80.8
57.2	14	61.4	62.4	63.4	64.4	65.4	66.4	67.4	68.4	69.4	70.4	71.4	72.4	73.4	74.4	75.4	76.4	77.4	78.4	79.4	80.4
59.0	15	61.0	62.0	63.0	64.0	65.0	66.0	67.0	68.0	69.0	70.0	71.0	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0	80.0
60.8	16	60.6	61.6	62.6	63.6	64.6	65.6	66.6	67.6	68.6	69.6	70.6	71.6	72.6	73.6	74.6	75.6	76.6	77.6	78.6	79.6
62.6	17	60.2	61.2	62.2	63.2	64.2	65.2	66.3	67.2	68.2	69.2	70.2	71.2	72.2	73.2	74.2	75.2	76.2	77.2	78.2	79.2
64.4	18	59.8	60.8	61.8	62.8	63.8	64.8	65.8	66.8	67.8	68.8	69.8	70.8	71.8	72.8	73.8	74.9	75.9	76.9	77.9	78.9
66.2	19	59.4	60.4	61.4	62.5	63.5	64.5	65.5	66.5	67.5	68.5	69.5	70.5	71.5	72.5	73.5	74.5	75.5	76.5	77.5	78.5
68.0	20	59.0	60.0	61.0	62.0	63.0	64.0	65.1	66.1	67.1	68.1	69.1	70.1	71.1	72.1	73.1	74.1	75.1	76.1	77.1	78.1
69.8	21	58.6	59.6	60.7	61.7	62.7	63.7	64.7	65.7	66.7	67.7	68.7	69.7	70.7	71.7	72.7	73.7	74.7	75.8	76.8	77.8
71.6	22	58.2	59.2	60.3	61.3	62.3	63.3	64.3	65.3	66.3	67.3	68.3	69.3	70.3	71.3	72.3	73.3	74.3	75.4	76.4	77.4
73.4	23	57.8	58.8	59.8	60.9	61.9	62.9	63.9	64.9	65.9	66.9	67.9	68.9	70.0	71.0	72.0	73.0	74.0	75.0	76.0	77.0
75.2	24	57.4	58.4	59.4	60.5	61.5	62.5	63.5	64.5	65.5	66.5	67.5	68.5	69.6	70.6	71.6	72.6	73.6	74.6	75.6	76.6
77.0	25	57.0	58.0	59.0	60.1	61.1	62.1	63.1	64.1	65.1	66.1	67.1	68.1	69.2	70.2	71.2	72.2	73.2	74.2	75.3	76.3
78.8	26	56.6	57.6	58.6	59.6	60.7	61.7	62.7	63.7	64.7	65.7	66.7	67.7	68.8	69.8	70.8	71.8	72.8	73.8	74.8	75.9
80.6	27	56.2	57.2	58.3	59.3	60.3	61.3	62.3	63.3	64.3	65.3	66.3	67.3	68.4	69.4	70.4	71.4	72.4	73.4	74.4	75.5
82.4	28	55.8	56.8	57.8	58.8	59.9	60.9	61.9	62.9	63.9	64.9	66.0	67.0	68.0	69.1	70.1	71.1	72.1	73.1	74.1	75.1
84.2	29	55.4	56.4	57.4	58.5	59.5	60.5	61.5	62.5	63.5	64.5	65.6	66.6	67.7	68.7	69.7	70.7	71.7	72.7	73.7	74.7
86.0	30	55.0	56.0	57.1	58.1	59.1	60.1	61.1	62.1	63.1	64.1	65.2	66.2	67.3	68.3	69.3	70.3	71.3	72.3	73.3	74.3

Table IV.—*continued.*

Temperature. Fahr.	Cent.	81 p. ct.	82 p. ct.	83 p. ct.	84 p. ct.	85 p. ct.	86 p. ct.	87 p. ct.	88 p. ct.	89 p. ct.	90 p. ct.	91 p. ct.	92 p. ct.	93 p. ct.	94 p. ct.	95 p. ct.	96 p. ct.	97 p. ct.	98 p. ct.	99 p. ct.	100 p. ct.
		Observed Percentage of the Alcoholometer.																			
32.0	0	86.4	87.4	88.3	89.2	90.2	91.2	92.2	93.1	94.0	95.0	95.9	96.8	97.7	98.6	99.5	100.3	101.2	—	—	—
33.8	1	86.1	87.0	88.0	89.0	89.9	90.8	91.8	92.8	93.7	94.6	95.6	96.5	97.4	98.3	99.2	100.0	100.9	—	—	—
35.6	2	85.7	86.6	87.6	88.6	89.6	90.5	91.5	92.4	93.4	94.3	95.2	96.1	97.0	97.9	98.9	99.8	100.7	—	—	—
37.4	3	85.3	86.3	87.3	88.3	89.2	90.2	91.2	92.1	93.0	94.0	94.9	95.8	96.7	97.7	98.6	99.5	100.4	—	—	—
39.2	4	85.0	86.0	87.0	88.0	88.9	89.9	90.8	91.8	92.7	93.7	94.6	95.5	96.4	97.4	98.3	99.2	100.1	101.0	—	—
41.0	5	84.7	85.6	86.6	87.6	88.5	89.5	90.5	91.4	92.4	93.3	94.3	95.2	96.2	97.1	98.0	98.9	99.8	100.7	—	—
42.8	6	84.3	85.3	86.3	87.3	88.2	89.2	90.1	91.0	92.0	93.0	93.9	94.9	95.9	96.8	97.7	98.7	99.6	100.5	—	—
44.6	7	83.9	84.9	85.9	86.9	87.9	88.8	89.8	90.7	91.7	92.6	93.6	94.6	95.6	96.5	97.4	98.4	99.3	100.2	—	—
46.4	8	83.6	84.6	85.6	86.5	87.5	88.5	89.4	90.4	91.3	92.3	93.3	94.3	95.3	96.2	97.1	98.1	99.0	99.9	—	—
48.2	9	83.2	84.2	85.2	86.2	87.1	88.1	89.1	90.0	91.0	92.0	93.0	94.0	95.0	95.9	96.8	97.8	98.7	99.7	100	—
50.0	10	82.8	83.8	84.8	85.8	86.8	87.8	88.7	89.7	90.7	91.7	92.7	93.7	94.7	95.6	96.5	97.5	98.5	99.4	100.4	—
51.8	11	82.5	83.4	84.4	85.4	86.4	87.4	88.4	89.4	90.4	91.4	92.4	93.3	94.3	95.3	96.2	97.2	98.2	99.1	100.1	—
53.6	12	82.1	83.1	84.1	85.0	86.0	87.0	88.0	89.0	90.0	91.0	92.0	93.0	94.0	95.0	95.9	96.9	97.9	98.8	99.8	—
55.4	13	81.8	82.8	83.8	84.8	85.7	86.7	87.7	88.7	89.7	90.7	91.7	92.7	93.7	94.6	95.6	96.6	97.6	98.6	99.5	—
57.2	14	81.4	82.4	83.4	84.4	85.4	86.4	87.4	88.3	89.3	90.3	91.3	92.3	93.3	94.3	95.3	96.3	97.3	98.3	99.3	—
59.0	15	81.0	82.0	83.0	84.0	85.0	86.0	87.0	88.0	89.0	90.0	91.0	92.0	93.0	94.0	95.0	96.0	97.0	98.0	99.0	100.0
60.8	16	80.6	81.6	82.6	83.6	84.6	85.6	86.6	87.6	88.6	89.6	90.7	91.7	92.7	93.7	94.7	95.7	96.7	97.7	98.7	99.7
62.6	17	80.2	81.2	82.2	83.2	84.2	85.2	86.2	87.2	88.2	89.3	90.3	91.3	92.4	93.4	94.4	95.4	96.4	97.4	98.5	99.5
64.4	18	79.9	80.9	81.9	82.9	83.9	84.9	85.9	86.9	87.9	88.9	89.9	91.0	92.0	93.0	94.0	95.1	96.1	97.1	98.2	99.2
66.2	19	79.5	80.5	81.6	82.6	83.6	84.6	85.6	86.6	87.6	88.6	89.6	90.7	91.7	92.7	93.7	94.8	95.8	96.9	97.9	98.9
68.0	20	79.1	80.1	81.2	82.2	83.2	84.2	85.2	86.2	87.2	88.2	89.2	90.3	91.3	92.4	93.4	94.5	95.5	96.6	97.6	98.6
69.8	21	78.7	79.7	80.8	81.8	82.8	83.8	84.8	85.9	86.9	87.9	88.9	90.0	91.0	92.0	93.1	94.1	95.2	96.3	97.3	98.4
71.6	22	78.4	79.4	80.4	81.4	82.4	83.4	84.4	85.5	86.5	87.6	88.6	89.6	90.7	91.8	92.8	93.9	94.9	96.0	97.0	98.1
73.4	23	78.0	79.0	80.1	81.1	82.1	83.1	84.1	85.1	86.1	87.2	88.3	89.3	90.4	91.4	92.4	93.5	94.6	95.7	96.7	97.8
75.2	24	77.6	78.6	79.7	80.7	81.7	82.7	83.7	84.7	85.7	86.8	87.9	88.9	90.0	91.1	92.1	93.2	94.3	95.3	96.4	97.5
77.0	25	77.3	78.3	79.3	80.3	81.3	82.3	83.4	84.4	85.4	86.5	87.5	88.6	89.7	90.7	91.8	92.9	93.9	95.0	96.1	97.2
78.8	26	76.9	77.9	78.9	79.9	80.9	81.9	82.9	84.0	85.0	86.1	87.2	88.2	89.3	90.4	91.5	92.5	93.6	94.7	95.8	97.0
80.6	27	76.5	77.5	78.5	79.5	80.5	81.6	82.6	83.6	84.7	85.7	86.8	87.9	89.0	90.0	91.1	92.2	93.3	94.4	95.5	96.7
82.4	28	76.1	77.1	78.2	79.2	80.2	81.3	82.3	83.3	84.3	85.4	86.5	87.5	88.6	89.7	90.8	91.9	93.0	94.1	95.2	96.4
84.2	29	75.7	76.8	78.8	78.8	79.8	80.9	81.6	83.0	84.0	85.0	86.1	87.2	88.2	89.3	90.4	91.6	92.7	93.8	94.9	96.1
86.0	30	75.3	76.4	77.4	78.4	79.4	80.5	81.5	82.6	83.6	84.7	85.8	86.9	87.9	89.0	90.1	91.2	92.4	93.5	94.6	95.8

Table V.*—*Table by* Gay-Lussac, *showing the Dilution per cent. of Water required to produce a stronger solution of Alcohol to a weaker one.*

The horizontal column at the top of the table denotes the per cent. of the stronger Alcohol, and the vertical columns below the volume of water which is to be added to 100 volumes of it, to produce spirit of the strength shown in the left-hand column.

Desired Strength	100 vols. of Alcohol of per cent. by vol.								
per ct.	90	85	80	75	70	65	60	55	50
85	6·56								
80	13·79	6·83							
75	21·89	14·48	7.20						
70	31·05	23·14	15·35	7·64					
65	41·53	33·03	24·66	16·37	8·15				
60	53·05	44·48	35·44	26·47	17 58	8 76			
55	67·87	57·90	48·07	38·32	28 63	19 02	9·47		
50	84·71	73.90	63·04	52·43	41·73	31·25	20·47	10·35	
45	105·34	93·30	81·38	69·54	57·78	46·09	34·46	22·90	11·41
40	130·80	117·34	104·01	90·76	77·58	64·48	51·43	38·46	25·55
35	163·28	148·01	132·88	117·82	102·84	87·93	73·08	58·31	43·59
30	206·22	188·57	171·05	153·61	136·04	118·94	101·71	84·54	67·45
25	266·12	245·15	224·30	203·53	182·83	162·21	141 65	121·16	100·73
20	355·80	329·84	304·01	278·26	252·58	226·98	201·43	175 96	150·55
15	505·27	471·00	436·85	402·81	368 83	334 91	301·07	267·29	233·64
10	804·54	753·65	702·89	652·21	601·60	551·06	500 59	450·19	399·85

The percentage by volume of absolute alcohol may be converted into percentage by weight, by multiplying by ·793811, the sp. gr. of absolute alcohol, and dividing the product by the sp. gr. of the sample. The quotient is the number of pounds of alcohol in 100 pounds of the given spirit. Thus: Suppose 1,000 grains by measure of alcohol to weigh 950·92 grains, and to contain (*see* Table II.) 40·63 per cent. by volume of absolute alcohol, what per cent. by weight does the sample contain?

* It must be observed that, owing to the difference in sp. gr. of absolute alcohol, and that taken as the standard in the preceding tables, none of these are perfectly accurate, since the densities given in them are proportionate to alcohol having a higher specific gravity than that which has been assigned by chemists to the pure anhydrous substance.

·793811 × 40·63=32·25254093, and this product divided by ·95092=33·917, the true percentage by weight of absolute alcohol in the sample.

4. *Method based on the Specific Gravity, or Percentage by Weight.*—The specific gravity being ascertained and Table II. used in precisely the same manner as in the "method by volume," already described.

The percentage by weight may be converted into percentage by volume, by multiplying the former by the sp. gr. of the sample and dividing the product by the sp. gr. of absolute alcohol. This is merely the reverse of the operation described above.

The preceding methods of alcoholometry, as well as all others depending on the sp. gr., refer to *unsweetened spirits* only; and are inapplicable to those holding sugar in solution, or any other organic matter capable of altering the sp. gr. For sweetened spirits, fermented worts, wine, beer, &c., one or other of the following processes must be adopted:—

5. *By Distillation*, as originally proposed by Gay-Lussac. 300 parts of the liquor under examination (measured in a graduated glass tube) are placed in a retort or small still, and a quantity exactly equal to one-third (*i.e.*, 100 parts) carefully drawn over; a graduated glass tube* being used as a receiver, and the operation stopped as soon as the distillate reaches the hundredth degree. The alcoholic strength of the distilled liquor is then ascertained by any of the usual methods, and the result divided by 3, when the percentage of alcohol in the original liquor is at once obtained. If, from want of attention, more than 100 parts should be distilled over, the number which expresses the rela-

* Mulder, in his "Chemistry of Wine," recommends this receiver to be shaped like a bottle, with its neck, or tubular part, bent at right angles above the line of its scale, and that it should be set in the centre of a glass jar kept filled with very cold water.

tion of the volume of the distilled product to the original bulk of the liquor tested, must be employed as the divisor. Thus, if 106 parts of liquor have distilled over (instead of 100), containing 33 per cent. of alcohol, the 300 must be divided by 106, which gives 2·83, and the 33 per cent. by this 2·83, which gives 11·66 per cent., the true proportion of alcohol in the original liquor. The strength at "proof" may be calculated from this in the usual way.

To ensure accurate results, the acidity (if any) of the liquor must be neutralized with carbonate of sodium, prior to distillation. It is also advisable to add 8 per cent. or 10 per cent. of common salt to the liquid in the retort or still; this, by raising the boiling-point, causes the whole of the spirit to pass over into the receiver before the distillate has reached the required measure. This applies more particularly to weak liquors. With those of greater strength, such as the stronger wines, it is better to distil over 150 parts, and divide the result by 2 instead of 3. To liquors stronger than 25 per cent. by volume of alcohol, or about 52 per cent. to 54 per cent. "under proof," add about an equal volume of water to the liquor in the still, and draw over a quantity equal to that of the sample tested; when the alcoholic strength of the distillate gives, without calculation, the true strength sought. To liquors stronger than 48 per cent. to 50 per cent. (14 to 12 "under proof") add thrice their bulk of water, and do not stop the process until the volume of the distillate is double that of the sample tested, when the percentage obtained must also be doubled. In each case a proportionate quantity of salt is employed.

The following is the method adopted in the Inland Revenue and Customs Laboratories for the estimation of the percentage of alcohol in wines, liqueurs, &c. A measure flask is filled up to a mark on its neck, with the wine, which is then carefully transferred to a distilling flask or retort,

the traces of wine remaining in the former vessel being rinsed out with small quantities of distilled water, and the rinsings added to the wine in the latter vessel. About two-thirds of the contents of the retort are then distilled over into the clean measure flask, and made up to the original bulk with distilled water, at the same temperature as the sample was previous to distillation. The strength is then taken by Sikes' hydrometer, and this (if "under proof") deducted from 100, gives the percentage of proof spirit in the wine. Thus:—Strength of distillate = 74·6 under proof = 25·4 per cent. proof spirit.

6. *From the Temperature of the Vapour*, as originally proposed by Gröning. The bulb of a thermometer is thrust through a cork into the head of the still, or other vessel employed, and the temperature of the vapour in which it is immersed being noted, is sought in the following table:—

TABLE VI.—*Showing the Alcoholic Content, by Volume, of Boiling Spirits, and of their Vapour, from the Temperature of the latter, as observed by a Thermometer.* By GRÖNING.

Temperature of the Vapour. Fahr.	Alcoholic content of the Distillate per cent.	Alcoholic content of the Boiling Liquid per cent.	Temperature of the Vapour. Fahr.	Alcoholic content of the Distillate per cent.	Alcoholic content of the Boiling Liquid per cent.
170·0	93	92	189·8	71	20
171·8	92	90	192·0	68	18
172·0	91	85	194·0	66	15
172·8	90½	80	196·4	61	12
174·0	90	75	198·6	55	10
174·6	89	70	201·0	50	7
176·0	87	65	203·0	42	5
178·3	85	50	205·4	36	3
180·8	82	40	207·7	28	2
183·0	80	35	210·0	13	1
185·0	78	30	212·0	0	0
187·4	76	25			

This method is admirably adapted to the purposes of the distiller and rectifier, as it furnishes a ready means of approximately determining the strength of the spirit passing over, at every part of the process of distillation, as well as that of the wash left in the still.

7. *From the Boiling-Point*, as originally proposed by the Abbé Brossard-Vidal. This method is founded on the fact that the boiling-points of mixtures of alcohol and water, unlike water alone, are scarcely disturbed by the addition of saline, saccharine, or extractive matter within certain limits. It hence offers a ready means of determining the proportion of alcohol present in spirits, wines, fermented liquors, &c., with sufficient accuracy for all ordinary purposes. In applying it, a thermometer, with a large bulb and a narrow bore, and a movable scale graduated from 178·5° to 212° Fahr., is usually employed.* Before using it as an alcoholometer, it is set, with its bulb immersed, in a small brass or copper boiler containing distilled water, which is then raised to the boiling-point, and the 212° of the scale accurately adjusted on a level with the surface of the mercury, should it vary from that point. This is necessary on account of variations of atmospheric pressure causing corresponding variations of the boiling-points of liquids. It is then ready for several hours' operations, and, generally, for an entire business day, without further adjustment. The little boiler is next filled with the liquor to be examined, and the lamp again lighted. The temperature, as shown by the scale of the instrument at the commencement of full ebullition being ascertained, may be sought in one of the tables on the next page, against which the

* The instrument in use in this country, and described above, is a simplified and improved form by Ure of an alcoholometer patented by Field in 1847. It is based upon the Abbé Brossard-Vidal's principle.

alcoholic content of the liquor will be approximately found.

TABLE VII.—*Exhibiting the Boiling-points of Mixtures of Alcohol and Water of the given strengths.* By GRÖNING.

Boiling-point. Fahr.	Alcohol per cent. by volume.	Boiling-point. Fahr.	Alcohol per cent. by volume.	Boiling-point. Fahr.	Alcohol per cent. by volume.	Boiling-point. Fahr.	Alcohol per cent. by volume.
205·34	5	187·16	30	179·96	55	175·46	80
199·22	10	185·0	35	179·42	60	174·92	85
195·8	15	183·38	40	178·7	65	174·2	90
192·38	20	182·12	45	177·62	70	173·14	95
189·50	25	181·58	50	176·54	75	172·0	100

TABLE VIII.—*Showing the Boiling-points of "under proof" Spirit.* By URE.

Boiling-points. Fahr.	Percentage strength.	Corresponding Sp. Gr.	Boiling-points. Fahr.	Percentage strength.	Corresponding Sp. Gr.
178·5	Proof.	·9200	185·6	50· U.P.	·9665
179·75	10· U.P.	·9321	189·0	60· ,,	·9729
180·4	20· ,,	·9420	191·8	70· ,,	·9786
182·1	30· ,,	·9516	196·4	80· ,,	·9850
183·4	40· ,,	·9600	202·0	90· ,,	·9920

This method does not answer well with spirituous liquors above "proof," owing to the variations of their boiling-point being so slight as not to be easily observed with accuracy; but with liquors under "proof," and particularly with wines, beer, and other fermented liquors, due care being observed, it gives results closely approximating to those obtained by distillation, and sufficiently accurate for all ordinary purposes. In testing strong alcoholic solutions it is, therefore, proper to dilute them with twice their bulk of water; and commercial spirits with an equal bulk of water; the results obtained being doubled or tripled as the case

may be. Salt should always be added to the liquid before experimenting on it.

In addition to giving the percentage of alcohol in spirituous liquors of all kinds, this instrument when jointly used with an ordinary hydrometer, reference being made to Table IX. (page 40), also shows the amount of saccharine and extractive matter in such fluids. For determining the quantity of these substances in wine proceed as follows:—First take the sp. gr. of the wine by the hydrometer, and then its boiling-point by the alcoholometer. By the tables find out with what sp. gr. this latter corresponds, and deduct it from that given by the hydrometer; the difference will, of course, be due to the saccharine and extractive. By consulting Table V., the amount of these in the fluid under examination may then be ascertained. Suppose the sp. gr. of the wine marks by the hydrometer ·980, and that the alcoholometer shows the presence of 55 per cent. of underproof spirit. Referring to the table it will be seen that this corresponds with a sp. gr. of ·970, which number deducted from ·980 leaves a difference of "10." Upon again referring to the table, we shall find under this number "4 oz., or 25 to 100," which signifies that 100 gallons of the wine contain 25 lbs. of saccharine and extractive matter combined with 45 gallons of proof spirit.

The amount of sugar and proof spirit in sweetened gins and cordials may also be determined by means of this instrument, reference being made to Table V. The method of proceeding is as follows:—First take the sp. gr. of the gin or cordial (suppose it to be ·958), then determine its alcoholic content by the alcoholometer (suppose this to be 15 per cent. under proof, this will correspond with sp. gr. ·938); deduct this from ·958 and search for the difference "20" in the tables, under "difference of gravity," where will be found "8 oz., or 50 to 100," which signifies that our specimen contains 8 oz. or

TABLE IX.—*Showing the lbs. of Sugar per Gallon in cordialized Spirits, with the Percentage to be added to the indicated Strength, per the Alcoholometer.*

Difference of Gravity in lbs. of Sugar per Gallon.		10 4oz. or 25 to 100	15 6oz. 37⅛ to 100	20 8oz. 50 to 100	25 10oz. 62½ to 100	30 12oz. 75 to 100	35 14oz. 87½ to 100	40 oz. 1·0	45 oz. 1·2	50 oz. 1·4	Difference of Gravity in lbs. of Sugar per Gallon.	
Sp. gr. of Spirit.	Per cent. of Spirit.										Per cent. of Spirit.	Sp. gr. of Spirit.
920	Proof.	1·6	2·5	3·4	4·4	5·3	6·2	7·1	8·1	9·0	Proof.	920
923	2·5	1·6	2·5	3·3	4·3	5·2	6·1	6·9	7·8	8·8	2·5	923
926	5·0	1·5	2·4	3·2	4·2	5·0	5·9	6·8	7·7	8·6	5·0	926
929	7·5	1·5	2·3	3·2	4·1	4·9	5·8	6·6	7·5	8·4	7·5	929
932	10·0	1·4	2·2	3·1	4·0	4·8	5·7	6·5	7·4	8·2	10·0	932
935	12·5	1·4	2·2	3·1	3·9	4·7	5·5	6·3	7·2	8·0	12·5	935
938	15·0	1·4	2·1	3·0	3·8	4·6	5·4	6·2	7·0	7·8	15·0	938
940	17·5	1·3	2·1	2·9	3·7	4·5	5·3	6·0	6·8	7·6	17·5	940
943	20·0	1·3	2·0	2·8	3·6	4·4	5·2	5·9	6·7	7·5	20·0	943
945	22·5	1·3	2·0	2·7	3·5	4·3	5·0	5·7	6·5	7·3	22·5	945
948	25·0	1·2	1·9	2·6	3·4	4·1	4·8	5·5	6·3	7·0	25·0	948
950	27·5	1·2	1·9	2·5	3·3	4·0	4·7	5·3	6·1	6·8	27·5	950
952	30·0	1·1	1·8	2·4	3·1	3·8	4·5	5·1	5·8	6·5	30·0	952
954	32·5	1·1	1·7	2·3	3·0	3·6	4·3	4·8	5·5	6·2	32·5	954
956	35·0	1·0	1·6	2·2	2·9	3·5	4·1	4·6	5·3	6·0	35·0	956
958	37·5	1·0	1·6	2·1	2·8	3·4	3·9	4·4	5·1	5·8	37·5	958
960	40·0	0·9	1·5	2·0	2·7	3·2	3·8	4·3	4·9	5·5	40·0	960
962	42·5	0·9	1·5	2·0	2·6	3·1	3·6	4·1	4·7	5·3	42·5	962
964	45·0	0·9	1·4	1·9	2·5	3·0	3·5	4·0	4·6	5·1	45·0	964
965	47·5	0·8	1·4	1·9	2·4	2·9	3·4	3·9	4·4	4·9	47·5	965
967	50·0	0·8	1·3	1·8	2·3	2·8	3·3	3·8	4·3	4·8	50·0	967
969	52·5	0·7	1·2	1·7	2·2	2·6	3·1	3·6	4·1	4·5	52·5	969
970	55·0	0·7	1·2	1·6	2·0	2·4	2·9	3·4	3·8	4·2	55·0	970
972	57·5	0·6	1·1	1·5	1·9	2·2	2·7	3·1	3·5	3·9	57·5	972
973	60·0	0·6	1·0	1·4	1·8	2·1	2·5	2·9	3·3	3·6	60·0	973
974	62·5	0·6	1·0	1·3	1·7	2·0	2·4	2·7	3·1	3·5	62·5	974
976	65·0	0·5	0·9	1·2	1·5	1·8	2·2	2·5	2·8	3·1	65·0	976
977	67·5	0·5	0·8	1·1	1·4	1·7	2·0	2·3	2·6	2·9	67·5	977
979	70·0	0·4	0·7	1·0	1·3	1·5	1·8	2·1	2·4	2·6	70·0	979
980	72·5	0·4	0·7	0·9	1·1	1·3	1·6	1·9	2·1	2·3	72·5	980
982	75·0	0·3	0·0	0·8	1·0	1·2	1·4	1·6	1·8	2·0	75·0	982
983	77·5	0·3	0·5	0·7	0·9	1·0	1·2	1·4	1·6	1·8	77·5	983
984	80·0	0·2	0·4	0·6	0·8	0·9	1·0	1·2	1·4	1·6	80·0	984
986	82·5	0·2	0·3	0·5	0·7	0·8	0·9	1·0	1·2	1·4	82·5	986
988	85·0	0·2	0·2	0·4	0·6	0·7	0·8	0·9	1·0	1·2	85·0	988
990	87·5	0·1	0·2	0·3	0·5	0·6	0·7	0·8	0·9	1·0	87·5	990
992	90·0	0·1	0·1	0·2	0·4	0·5	0·6	0·7	0·8	0·9	90·0	992
994	92·5	—	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	92·5	994
996	95·0	—	—	0·1	0·2	0·3	0·4	0·5	0·6	0·7	95·0	996
998	97·5	—	—	—	0·1	0·2	0·3	0·4	0·5	0·6	97·5	998

$\frac{1}{2}$ lb. of sugar to the gallon. Look down the column headed "the percentage of proof spirit" until the number "15" is reached, on a line with this, and in the third column headed

"20" / 8oz. / 50 to / "100" will be found the number "3," which added to 15

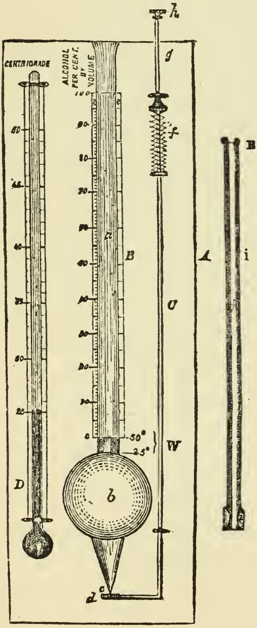
makes the total on the bulk 18 per cent. of under-proof spirit, with $\frac{1}{2}$ lb. of sugar to the gallon, or 50 lbs. of the 100 gallons.

For determining the strength of malt liquors, the alcoholometer is employed, in conjunction with a saccharometer, a testing-glass, and a slide rule. The saccharometer is so graduated as to show, when placed in the testing-glass containing the beer, the number of pounds per barrel the liquid is heavier than water; and the percentage of proof spirit having been determined by the alcoholometer, the slide is so arranged as to indicate how many pounds of saccharine have been decomposed to produce the percentage of spirit found. By adding this to the amount of saccharine, as denoted by the saccharometer, the original weight of the wort before fermentation is arrived at. Also, the slide rule can be so manipulated as to show the observer at a glance the cost between any two beers. The saccharometer has been graduated for temperatures at 60° Fahr., and, except where extreme accuracy is required, a little divergence one way or the other from this point is of no consequence. When, however, nice results are desirable, an allowance of $\frac{3}{10}$ths of a pound for every 10 degrees above 60° must be added to the gross amount recorded by the slide rule; on the contrary, for every 10 degrees below 60, $\frac{3}{10}$ths of a pound must be subtracted.

8. *From the Expansion of the Liquid when Heated* (Silbermann's Dilatometer). The expansion of alcohol between 0° and 212° Fahr. is triple that of water; and between 77°

and 122° Fahr. it is much greater. Between – 14° and – 98° Fahr. the rate of expansion is about the ·00047th part in volume for every degree of Fahrenheit's scale. The measurement of this expansion has been proposed as a new and ready method of alcoholometry, adapted to nearly all spirituous and fermented liquids. SILBERMANN's instrument, which is based on it, simply consists of a flat brass or ivory plate (A), on which are fixed a mercurial thermometer (D) graduated from 25° to 50° Cent. (= 77° to 122° Fahr.);

FIG. 5.



and the DILATOMETER (B), which is a glass pipette open at both ends. A valve of cork, or vulcanized india-rubber, closes the tapering end (c); this valve is attached to a movable rod (C) which is fastened to the supporting-plate, and connected with a spring (f) and a handle (g) bearing a four-threaded screw, by which the lower orifice of the pipette can be opened or closed at will. In use, the pipette is filled with the liquid under examination, to a little above the zero point (0) on the scale. This is effected by suction, by means of a little piston of leather (i), which fits tightly in the long and wider limb of the pipette; the valve (d) being previously opened by turning the knob (h). The proper quantity of liquid being introduced, and the lower end closed, the piston is moved up and down two or three times, for the purpose of drawing the air-bubbles and absorbed air out of the liquid, the presence of which would

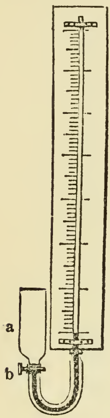
vitiate the results of the trial. To allow the piston to be withdrawn without any shock, or the danger of dividing the column abruptly, the rod attached to it is made hollow throughout. In using it the operator applies the ball of his forefinger to the top of the piston-rod (*E*), in order to create a vacuum as he raises it; and then withdraws it to re-admit the air when he thrusts it down or removes it from the tube. The excess of liquid (if any) in the pipette is then run off until its upper surface is exactly level with the zero (o) of the scale, at 25° C., to which it is raised by immersion in a water-bath of that temperature, as observed by the thermometer; the operation of getting rid of any excess of liquid is performed by very cautiously turning the rod which depresses the valve. The whole apparatus is again immersed in the water-bath; and held by the upper portion of the plate, kept in gentle motion with the hand, until the temperature rises to exactly 50° C., when the coefficient of expansion is obtained, and hence also the proportion of alcohol, the scale of the instrument being so graduated, from actual experiments previously made upon mixtures of known composition, as give very nearly and at once the percentage of alcohol by volume.

Both FIELD's and SILBERMANN's alcoholometers possess the advantages over GAY-LUSSAC's distillation method, that they substitute a comparatively easy and expeditious process for a tedious and difficult one. Silbermann asserts that his dilatometer test is free from one objection he urges against the boiling test as effected by Field's instrument—viz., that liquids may be heated beyond their boiling-points without ebullition, and that under certain conditions the thermometer attached to Field's instrument when immersed in them may register so many degrees above the real temperature, and so give rise to a very erroneous indication.

9. *From the Tension of the Vapour* (GEISSLER'S ALCO-

HOLOMETER). This method, for which we are indebted to M. GEISSLER, of Bonn, depends on the measurement of the tension or elastic force of the vapour of the liquid, as indicated by the height to which it raises a small column of mercury. The spirit, wine, or other liquid, of which it is desired to ascertain the strength, is put into the little flask (a), which, when completely filled, is screwed on to the curved glass-tube which contains the mercurial column (which is inverted for the purpose), and is closed by the stop-cock (b). The instrument is then placed erect, and the flask and lower part of the tube immersed in a water-bath, as in the previous method. The number on the graduated scale of the instrument corresponding to the height of the mercury, at the boiling-point of the liquid under examination, gives the percentage of alcohol by volume.

FIG. 6.



This method furnishes approximate results with great facility and expedition; and, with proper care, these do not vary more than $\frac{1}{3}$ to $\frac{1}{2}$ of 1 per cent. from those obtained by distillation. Better results are obtained by having the diameter of the part of the tube at which the surface of the mercury is acted on by the vapour a little larger than that of the longer limb, and by previously abstracting the air from the sample, as in SILBERMANN'S method. When this method is adopted, it will be first necessary to remove any carbonic acid, by means of caustic lime.

10. From the *difference between the sp. gr. before and after ebullition* (TABERIÉ'S METHOD AND ŒNOMETER).—The sp. gr. of the sample is first accurately determined by any of the usual methods. It is next carefully evaporated, in an open vessel, to one half its volume. The residuum, when cold, is made up with pure water to exactly its original measure at

its original temperature, and the sp. gr. again ascertained. The difference between the two being due to the spirit originally present, furnishes the means of calculating a new sp. gr., from which the percentage richness of the sample may be obtained by mere inspection of the tables. The observed sp. gr. is the true one, whenever the liquid, after ebullition and restoration to its original volume, has the same sp. gr. as water (*i.e.*, 1·000), at 60° Fahr. Taberié employs a peculiar instrument, which he calls an œnometer; but its use is not essential to his method of alcoholometry. The results are, of course, only approximate, though sufficient for all ordinary purposes. Professor MULDER, however, says that he prefers it to any of the previous methods; and that the results, with care, are almost as accurate as those obtained by distillation.

11. *By means of Carbonate of Potash* (BRANDE'S METHOD).—The liquid for trial is poured into a long, narrow glass tube (graduated centesimally), until the vessel is half-filled, and, after the addition of about 12 per cent or 15 per cent. of a strong solution of subacetate of lead, or a little finely powdered litharge, is agitated until the colour is entirely, or nearly, removed. Anhydrous carbonate of potash, in powder, is next added until it sinks undissolved, even after prolonged agitation of the liquid. The whole is now allowed to repose for a short time, when the alcohol is seen floating on the top of the aqueous portion of the liquid in a well-marked stratum. Its quantity, read off by means of the graduations of the tube, and doubled, gives the percentage richness of the sample in alcohol, by volume.

This process answers well with cordials, wines, and the stronger ales; but with very weak liquids it is not to be relied on. The whole operation may be performed in from two to five minutes, and, with the exceptions above stated, furnishes very reliable approximate results. In most cases the

decoloring part of the process may be omitted. The alcohol thus separated has a sp. gr. of from 0·8061 to 0·8118, and contains 3 per cent. or 4 per cent. of water; but for ordinary purposes it may be regarded as pure alcohol.

13. *Alcoholometry of Minute Quantities of Liquid.*—When only a few drops, or a quantity too small for the application of the preceding methods, can be obtained, an organic analysis by combustion with oxide of copper may be had recourse to, and the quantity of absolute alcohol calculated from that of the resulting carbonic anhydride and water; care being previously taken to free the sample from other volatile bodies, if it contains them.

The duties on spirits in England are charged on the number of proof gallons they contain, which is ascertained by gauging or weighing the spirit, and then trying its strength by Sikes' hydrometer. The percentage of proof spirit multiplied by the number of gallons gives the net amount of proof spirit to be charged.

"PROOF STRENGTH" is an arbitrary standard, adopted for the purpose of facilitating calculations, for which it is well suited; although pure alcohol would, for this purpose, be more simple. As defined by Act of Parliament, 58 Geo. III., c. 28, "proof spirit" is such "as shall, at the temperature of 51° of Fahrenheit's thermometer, weigh exactly twelve thirteenth parts of an equal measure of distilled water."

Taking, therefore, water at 51° Fahr. as unity, the sp. gr. of "proof spirit" at 51° Fahr. is $\frac{12}{13}$ of 1·000 or ·92308 When such spirit is raised to the temperature of 60° Fahr., its density is ·91984.

Spirit at "proof" contains very nearly equal weights of absolute alcohol and water; the exact proportions according to recent experiments are:—

By Weight.	By Volume.		Sp. gr. at 60° Fahr.
	Bulk before admixture.	Bulk after admixture and condensation.	
Alcohol. Water.	Alcohol. Water.		
100·00 + 103·08	100·00 + 81·80	175·23	·91984
49·24 + 50·76	*57·06 + 46·68	100·00	

* 57·06 vol. of absolute alcohol × ·793811 = 45·30 grains by weight in 100 volumes of proof spirit, or 4·53 lbs. in a gallon.

The standard alcohol of the Revenue authorities, and that on which Gilpin's Tables are founded, is of the sp. gr. ·825 at 60° Fahr., which is said to contain, by weight, 89 per cent. of absolute alcohol, and 92·6 per cent. by volume, which corresponds to 62·2 over proof.

It is of great importance to the spirit dealer to be able to estimate correctly the number of "proof gallons" in any quantity of his commodities, or in the whole or any portion of his stock, as disagreeable errors frequently result from ignorance on this point. Calculations of this kind are extremely simple. Thus, when we find, by the hydrometer, that a given sample of spirit is 10 per cent. over proof, it means, that 100 gallons of such spirit contain as much alcohol as 110 gallons of proof spirit.

In over-proof spirit, the percentage o. p. practically represents the quantity of water which the given spirit requires to reduce it to proof. By adding this percentage over proof to 100, we obtain a number which, multiplied by any number of gallons, and divided by 100, gives the exact number of proof gallons which is contained in any quantity of the spirit referred to. Thus:—A puncheon of rum gauged at 91 galls., and shown by the hydrometer to be 21 o. p., contains:—

21 o. p. of sample added to 100	121
No. of gallons of rum	91
100)	11011
No. of gallons of proof spirit	110·11

In like manner, when a spirit is said to be 11 u. p., or under proof, it means that 100 galls. of such spirit contain 11 galls. of water and 89 galls. of "proof spirit." By deducting the percentage under proof from 100, we not only obtain the number of proof galls. contained in 100 galls. of such spirit, but, as in the last case, a factor which multiplied by any number of galls., and divided by 100, gives the exact number of "proof gallons" contained in any quantity of the given strength. Thus:—An ullage brandy piece containing 45 galls. of spirit at 10 u. p., would have the proof value of—

Per cent. u. p. of sample 10, subtracted from 100	90
No. of gallons	45
100)	4050
Quantity of proof spirit	40·50

Or exactly $40\frac{1}{2}$ gallons.

The strength of absolute alcohol (sp. gr. ·7938) is $75\frac{1}{4}$ per cent. over proof. It therefore contains $175\frac{1}{4}$ per cent of "proof spirit," whilst proof spirit (sp. gr. ·91984) contains 57·06 per cent. of "absolute alcohol;" both being by measure or volume. Thus:—

$$\frac{\text{Measure of alcohol} \times 175\frac{1}{4}}{100} = \text{equiv. measure of proof spirit.}$$

and—

$$\frac{\text{Measure of proof spirit} \times 57{\cdot}06}{100} = \text{equiv. measure of abs. alcohol.}$$

From which we derive the "constant multipliers" 1·7525 (or roughly $1\frac{3}{4}$), and ·5706, applicable to any number of volumes or gallons. For—

Measure of alcohol $\times$ 1·7525 = equiv. measure of proof spirit.

and—

Measure of proof spirit $\times$ ·5706 = equiv. measure of alcohol.

To ascertain what quantity of a spirit at any given strength is equivalent to or contains 100 lbs. of absolute alcohol, we have only to divide the constant number 2207·7 by the proof value per cent. of such spirit.* Thus—for a spirit 12 u. p.—this would be

$$100 - 12 = 88 \text{ per cent. of proof spirit;}$$

and—

$$\frac{2207 \cdot 7}{88} = 25 \cdot 1 \text{ gal. (nearly).}$$

That is, $25\frac{1}{10}$ gallons of such spirit would contain 100 lbs. of absolute alcohol.

By removing the decimal point one place to the right, we have the equiv. measure of 1000 lbs. By removing it one, two, or three places to the left, we have it respectively for 10 lbs., 1 lb., and $\frac{1}{10}$ lb.; from which the equivalent for all other weights may be easily obtained.

By reversing the above operation, the measure of alcohol corresponding to any given weight of spirit, at any strength, may also be easily found.

The weight of 1 gallon of absolute alcohol being 7·938 lbs.; that of 1 gallon of proof spirit, 9·2 lbs.; and that of the alcohol in 1 gallon of proof spirit, 4·53 lbs.; the weight of any number of gallons or volumes of either, and their equivalents, may be easily found. Thus:—

gallons of alcohol $\times$ 7·938 = lbs. weight of alcohol.

" proof spirit $\times$ 9·2 = lbs. weight of proof spirit.

and—

gallons of alcohol $\times$ 16·121 = lbs. weight of proof spirit.

" proof spirit $\times$ 4·53 = content in lbs. weight of alcohol.

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* This number is obtained thus:—

$$\frac{100}{\cdot 79381} = 12 \cdot 6 \text{ (nearly),}$$

and—

$$12 \cdot 6 \times 175 \cdot 25 = 2207 \cdot 7.$$

In these cases the Excise officers carry their calculations to two figures of decimals, or $\frac{1}{100}$ths. Their plan is to reject the third decimal figure when less than 5; but to carry one to the next figure on the left hand, when it exceeds 5. Thus, 5·432 is set down as only 5·43; but 5·437 is written 5·44.

Formerly, spirit was said to be "1 to 3, 1 to 4, &c., over proof," by which was meant that 1 gallon of water added to 3 or 4 gallons of such spirit would reduce it to "proof." On the other hand, "1 in 5, or 1 in 8, under proof," meant that the 5 or 8 galls., as the case might be, contained 1 gal. of water, and the remainder represented the quantity of "proof spirit." This method of calculation has now long given way to the Centigrade system, which not only admits of greater accuracy, but is quite as simple. It should be adopted by every spirit-dealer in England, since it is employed by the Revenue officers, whose "survey" it is absolutely necessary that the trader should understand, in order that his own estimation of his stock and his business calculations should correspond with theirs.

Several other methods of alcoholometry, besides those already noticed, have been adopted at various times, but the majority of them possess so little accuracy as to be quite inapplicable to the purposes of trade, and of the laboratory. Thus, the strength was at one time estimated by what was called the "proof." A little of the spirit was poured upon a small quantity of gunpowder, contained in a spoon or saucer, so as just to moisten it, and was then inflamed. If at the end of the combustion the gunpowder took fire, the spirit was held to be "above proof;" if it only languidly fizzed or slowly burnt away, the spirit was said to be "proof;" but if the gunpowder failed to ignite, the spirit was esteemed "below proof." Hence arose the terms "proof" and "proof spirit," which have since been adopted by Act of Parliament.

Another method was that of dropping oil into the spirit; if the oil floated, the spirit was considered to be "under proof;" if it sank, it was described as "proof" or "over-proof." The gunpowder test is quite fallacious; for if a certain quantity of a spirit is capable of firing the gunpowder, a little excess of a spirit 20 or 25 per cent. stronger will often fail to do so, so much water being formed as to prevent the ignition. The "Preuve d'Holland" test, of the French, or the "Bead," is still frequently employed by persons unacquainted with the use of the hydrometer. It consists in shaking the spirit in a phial, and observing the size, number, and duration of the bubbles or beads, as they are called. The larger and more numerous these are, and the more rapidly they break and disappear, the stronger the spirit is presumed to be. This method is unreliable, as the presence of sugar or acid, even in minute quantities, will sometimes give to a weak sample the appearance of one many degrees stronger. Lovi's beads are also often employed to ascertain approximately the strength of spirit, when a hydrometer is not at hand.

The insufficiency of most of the methods of alcoholometry here referred to, throws us back on the Revenue System (Sikes' hydrometer), or on the specific gravity for unsweetened spirits. For sweetened spirits, as cordials, wines, beers, &c., there are none of the tests which give such accurate results as the distillation test, previously described as the Revenue Method.

The spirituous liquors of commerce being sold by measure, and not by weight, the methods of alcoholometry which give the results, per cent., by volume, are those we have chiefly explained. In the laboratory, the method by weight is that most generally employed in delicate processes, and in analyses. By weight, the percentage of alcohol remains the same for all temperatures, for the same sample; whilst by volume, the

percentage varies with the temperature of the liquid. This variation is the cause of the apparent increase and decrease which are frequently observed by spirit dealers in the liquids which compose their stock. Persons purchasing spirits during very warm weather, and paying for them according to their apparent quantity and strength, lose considerably by selling the same spirit when the weather becomes colder, without being conscious of such loss from the hydrometer. The reason of this is obvious; for, whilst the relative proportions of the alcohol to the water continue the same, the specific gravity and the volume alter with the temperature; the latter being increased by warmth, and decreased by cold, in exact opposition to the former. Accuracy requires, in all cases, that a spirituous liquid should be tested for its strength at the temperature at which it was measured, and measured at the same temperature at which its strength was determined.

A consideration of these facts has led to the introduction amongst spirit merchants of the system of weighing spirits, instead of measuring them, the weight of an imperial gallon at 60° Fahr. being taken as the standard gallon. This is the method adopted by the Inland Revenue, at all distilleries, for assessing the duty, and will be readily understood by the following example :—

		Cwts.	qrs	lbs.
Gross weight of full cask	=	13	2	27
Tare	=	2	2	5
Net weight of spirit	=	11	0	22

or 1254 lbs. Let us suppose the hydrometer indication to be 43·0, the weight per imperial gallon would be 8·903 lbs. (*see* Table X.), and $1254 \div 8{\cdot}903 = 140$ gallons.

Table X.—*Table for determining the Weight per Gallon of Spirits by Sikes' Hydrometer.*

Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.
0	8·154	8		17	8·443	25	
2	8·157	6	8·299	2	8·446	6	8·593
4	8·161	8	8·303	4	8.450	8	8·596
6	8·164	9	8·306	6	8·453	26	8·600
8	8·168	2	8·309	8	8·457	2	8·603
1	8·171	4	8·313	18	8·460	4	8 607
2	8·174	6	8·316	2	8·464	6	8·610
4	8·178	8	8·320	4	8·467	8	8·614
6	8·181	10	8·323	6	8·471	27	8·617
8	8·185	2	8·326	8	8·474	2	8 620
2	8·188	4	8·330	19	8·478	4	8·624
2	8·191	6	8·333	2	8·481	6	8·628
4	8·195	8	8·337	4	8·485	8	8·631
6	8·198	11	8·340	6	8·488	28	8 635
8	8·202	2	8·343	8	8·492	2	8·639
3	8·205	4	8·347	20	8·495	4	8·642
2	8·208	6	8·350	2	8·498	6	8·646
4	8·212	8	8·354	4	8·502	8	8·649
6	8·215	12	8·357	6	8·505	29	8·653
8	8·219	2	8·361	8	8·509	2	8·656
4	8·222	4	8·364	1	8·512	4	8·660
2	8·225	6	8·368	2	8·516	6	8·663
4	8·229	8	8·371	4	8·519	8	8·667
6	8·232	13	8·375	6	8·523	30	8·670
8	8·236	2	8·378	8	8·526	2	8·674
5	8·239	4	8·382	22	8·530	4	8·677
2	8·242	6	8·385	2	8·533	6	8·681
4	8·245	8	8·389	4	8·537	8	8·684
6	8·249	14	8·392	6	8·540	31	8·688
8	8·252	2	8·395	8	8·544	2	8·692
6	8·255	4	8·399	23	8·547	4	8·695
2	8·258	6	8·402	2	8 551	6	8·699
4	8·262	8	8·406	4	8·554	8	8·702
6	8·265	15	8·409	6	8·558	32	8·706
8	8·269	2	8·412	8	8·561	2	8·709
7	8·272	4	8·416	24	8·565	4	8·713
2	8·275	6	8·419	2	8·568	6	8·716
4	8·279	8	8·423	4	8·572	8	8·720
6	8·282	16	8·426	6	8·575	33	8·723
8	8·286	2	8·429	8	8·579	2	8·727
8	8·289	4	8·433	25	8·582	4	8·730
2	8·292	6	8·436	2	8·586	6	8·734
4	8·296	8	8·440	4	8·589	8	8·737

TABLE X.—*continued.*

Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication. on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.
34	8·741	42		51	9·050	59	
2	8·745	6	8·896	2	9·054	6	9·211
4	8·748	8	8·899	4	9·058	8	9·214
6	8·752	43	8·903	6	9·061	60	9·218
8	8·755	2	8·907	8	9·065	2	9·222
35	8·759	4	8·911	52	9·069	4	9·226
2	8·763	6	8·914	2	9·073	6	9·229
4	8·766	8	8·918	4	9·076	8	9·233
6	8·770	44	8·922	6	9·080	61	9·237
8	8·773	2	8·926	8	9·083	2	9·241
36	8·777	4	8·929	53	9·087	4	9·245
2	8·781	6	8·933	2	9·091	6	9·248
4	8·784	8	8·936	4	9·095	8	9·252
6	8·788	45	8·940	6	9·098	62	9·256
8	8·791	2	8·944	8	9·102	2	9·260
37	8·795	4	8·947	54	9·106	4	9·264
2	8·799	6	8·951	2	9·110	6	9·267
4	8·802	8	8·954	4	9·114	8	9·271
6	8·806	46	8·958	6	9·117	63	9·275
8	8·809	2	8·962	8	9·121	2	9·279
38	8·813	4	8·965	55	9·125	4	9·283
2	8·817	6	8·969	2	9·129	6	9·286
4	8·820	8	8·972	4	9·132	8	9·290
6	8·824	47	8·976	6	9·136	64	9·294
8	8·827	2	8·980	8	9·139	2	9·298
39	8·831	4	8·984	56	9·143	4	9·302
2	8·835	6	8·987	2	9·147	6	9·305
4	8·838	8	8·991	4	9·151	8	9·309
6	8·842	48	8·995	6	9·154	65	9·313
8	8·845	2	8·999	8	9·158	2	9·317
40	8·849	4	9·002	57	9·162	4	9·321
2	8·853	6	9·006	2	9·166	6	9·324
4	8·856	8	9·009	4	9·170	8	9·328
6	8·860	49	9·013	6	9·173	66	9·332
8	8·863	2	9·017	8	9·177	2	9·336
41	8·867	4	9·021	58	9·181	4	9·340
2	8·871	6	9·024	2	9·185	6	9·344
4	8·874	8	9·028	4	9·189	8	9·348
6	8·878	50	9·032	6	9·192	67	9·352
8	8·881	2	9·036	8	9·196	2	9·356
42	8·885	4	9·039	59	9·200	4	9·360
2	8·889	6	9·043	2	9·204	6	9·363
4	8·892	8	9·046	4	9·207	8	9·367

TABLE X.—*continued.*

Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.	Indication on Sikes' Hydrometer.	Weight per Gallon.
68	9·371	76	9·525	84	9·682	92	9·840
2	9·375	2	9·529	2	9·686	2	9·844
4	9·379	4	9·533	4	9·690	4	9·848
6	9·382	6	9·537	6	9·694	6	9·852
8	9·386	8	9·541	8	9·698	8	9·856
69	9·390	77	9·545	85	9·702	93	9·860
2	9·394	2	9·549	2	9·706	2	9·864
4	9·398	4	9·553	4	9·710	4	9·868
6	9·401	6	9·557	6	9·714	6	9·872
8	9·405	8	9·561	8	9·718	8	9·876
70	9·409	78	9·565	86	9·722	94	9·880
2	9·413	2	9·569	2	9·726	2	9·884
4	9·417	4	9·573	4	9·730	4	9·888
6	9·420	6	9·576	6	9·733	6	9·892
8	9·424	8	9·580	8	9·737	8	9·896
71	9·428	79	9·584	87	9·741	95	9·900
2	9·432	2	9·588	2	9·745	2	9·904
4	9·436	4	9·592	4	9·749	4	9·908
6	9·440	6	9·596	6	9·753	6	9·913
8	9·444	8	9·600	8	9·757	8	9·917
72	9·448	80	9·604	88	9·761	96	9·921
2	9·452	2	9·608	2	9·765	2	9·925
4	9·456	4	9·612	4	9·769	4	9·929
6	9·459	6	9·615	6	9·773	6	9·934
8	9·463	8	9·619	8	9·777	8	9·938
73	9·467	81	9.623	89	9·781	97	9·942
2	9·471	2	9·627	2	9·785	2	9·946
4	9·475	4	9·631	4	9·789	4	9·950
6	9·479	6	9·635	6	9·792	6	9·955
8	9·483	8	9·639	8	9·796	8	9·959
74	9·487	82	9·643	90	9·800	98	9·963
2	9·491	2	9·647	2	9·804	2	9·967
4	9·495	4	9·651	4	9·808	4	9·972
6	9·498	6	9·655	6	9·812	6	9·976
8	9·502	8	9·659	8	9·816	8	9·981
75	9·506	83	9·663	91	9·820	99	9·985
2	9·510	2	9·667	2	9·824	2	9·989
4	9·514	4	9·671	4	9·828	4	9·994
6	9·517	6	9·674	6	9·832	6	9·998
8	9·521	8	9·678	8	9·836	8	10·003
						100	10·007

CHAPTER II.

BREWING AND BEER.

Brewing may be defined as the art of making Beer, and constitutes one of our most important industries. Until very recently, malt, hops, and water were the only ingredients allowed by law to enter into the composition of beer, and this beverage was therefore described as an aqueous infusion of malted grain, which, after being boiled with hops, had undergone the vinous fermentation. The legal restrictions with regard to the ingredients allowed to be used in the brewing of beer have, by degrees, all disappeared; in 1846 sugar was allowed to be used as a substitute for malt. In 1862 the hop duty was repealed, and brewers have since been at liberty to use hop substitutes, and lastly, in 1880, with the repeal of the malt-tax, and the imposition of a beer duty, complete freedom in the choice of materials was granted to brewers: in fact, they were given what has been called a "free mash-tun." At the present time beer may be brewed from any suitable materials, the only legal restriction being against the use of ingredients injurious to health. The old definition of beer, therefore, no longer holds good; and this beverage must now be more correctly described as a saccharine fluid flavoured with hops, or other aromatic bitters, which has been rendered alcoholic by fermentation.

The word "Beer" is now the common generic term for all fermented malt liquors, and, indeed, for all other

beverages prepared by a process of brewing. Whenever the term is used in a special sense, it is with a descriptive prefix—as, for example, spruce beer, ginger beer, &c.

Ale and wine are fabled to have been invented by Bacchus; the former, in Egypt, where the soil and climate would not permit of the cultivation of the grape. Herodotus ascribes the origin of the art of brewing to Isis, the wife of Osiris, and notices *zythum* (ζῦθος), a beer obtained from barley. Malt liquor was undoubtedly employed as a beverage in the fifth century before Christ; and, probably, very much earlier. Xenophon distinctly alludes to it in his famous retreat, B.C. 401. Aristotle speaks of "beer drunkenness;" and Theophrastus calls it "barley wine." The Romans learned the art of brewing from the Egyptians, and gave the liquor thus made the appropriate name of *cerevisia* (quasi-*Cererisia*), from its being the product of corn, the gift of Ceres. The most celebrated beer of ancient times was the *Pelusian potation*, so named after a town at the mouth of the Nile where beer was prepared in great perfection. The use of beer was likewise known to the ancient Gauls and Germans, and probably also to most other ancient nations inhabiting the temperate zone. Pliny says "*Zythum* is made in Egypt, *celia* and *ceria* in Spain, and many other sorts of beer in Gaul." In our own country, ale was early known and valued as a beverage, for Eumenes in A.D. 296, says, "Britain produces such abundance of corn that it is sufficient to supply not only bread, but a liquor comparable with wine."

The art of brewing beer in this country appears to have been obtained either from the Romans or the Saxons. According to Verstegan, "This excellent and healthsome liquor, beere, anciently called ale, as of the Danes it yet is, was of the Germans invented and brought into use." Alehouses are mentioned in the laws of Ina, king of

Wessex, A.D. 680. Alebooths were regulated by law, A.D. 728. By the beginning of the thirteenth century ale was drunk generally in England. By a statute of James III. of Scotland, it was made a capital offence to mix wine with beer, A.D. 1482. In 1492 a licence was granted to a brewer at Greenwich to export 50 tons of that "ale" called "beer" or "bere;" the distinction between the two apparently being, that the latter was flavoured with wormwood or other bitters; whereas ale was not. Ale was originally made from barley-malt and yeast alone, and those who put in anything else were held to sophisticate the liquor. Hops were introduced A.D. 1524; and to this date modern, or hopp'd, beer, may be traced.

By statute of James I. the "ale" called "bere" was taxed, and "one quart of the best thereof" ordered to be sold for a penny, A.D. 1610. Alehouses were first licensed in 1621; and during the reign of Charles II. were, together with all malt liquor, placed under the control of the Excise (A.D. 1660). Beer is now the common beverage in all European countries where the vine is not a subject of rustic husbandry.

Varieties.—There are several varieties of malt liquor, but they may be divided into two great classes—ale, or light-coloured beers; and porter, or black beers. Of the first class there are several kinds, such as pale ale, mild ale, bitter ale, and table beer; the second class includes several kinds of black beer, such as porter, stout, and cooper.

The two great classes of malt liquor above referred to, are, independently of mere differences of strength, excellence, and commercial value, practically subdivided into an almost infinite number of varieties. Every county, every town, and almost every brewer, is distinguished by the production of a different flavoured beer, readily perceived, and highly

appreciated by its respective votaries. These differences may be traced to:—variations in the quantity and quality of the materials employed in their manufacture; the temperature of the water used for mashing; the duration of the boiling; the temperature at which the fermentation is conducted, and the extent to which it is carried; together with numerous other circumstances, which, though usually of an accidental and uncertain character, are nevertheless sufficient to affect the flavour and quality of a brewing. Among these, those depending on the condition of the building, the locality, the apparatus, the water, the management, &c., are not the least important. In general, however, when the same quantity and quality of materials are employed, and the same time allowed for the maturation of the liquor, the chief causes of this diversity will be found to depend on the water used in the brewing, and the method followed in the preparation of the malt. Thus Bavarian, Scotch, and Burton ales differ in character from other ales chiefly from being fermented at a lower temperature, and from the water employed in the brewing being that usually denominated "hard," whilst porter and stout differ from all these because they are brewed from a mixture of pale and roasted malt. It is from causes like these, though apparently trivial, that the many varieties of malt liquor met with at the present day, originate.

During the last few years attempts have been made to introduce lager beer into this country; at first it was imported, but now lager beer breweries are being established here, and there is every prospect that this description of beer, which is so largely consumed in Germany and America, will grow in public favour; but its production involves considerable changes in the plant and system of brewing at present adopted. After having described the different materials used in brewing and the various stages of the

process, we shall refer in greater detail to the different varieties of beer enumerated above.

Materials.—Water, malt, and hops are the principal constituents of beer, but sugar and raw grain are also now largely used in place of malt, and occasionally other bitter flavouring materials are substituted for hops.

WATER.

This constituent is known to exercise a very marked influence on the quality of beer. It is of the first importance that a brewing water should be free from organic contamination, as the presence of only the slightest trace of decaying organic matter produces the most disastrous results. The general opinion of English brewers is that a permanently hard water is best suited for ales, especially for those of the pale ale type; but for black beers, such as porter and stout, a soft water is preferred. The hardness of water is said to be *temporary* when it is due to the carbonates of calcium and magnesium, which are removed by boiling; and *permanent*, when due to the sulphates and other soluble salts of the same metals. Of late years hard water has been preferred by many brewers, on the ground that beer brewed with it is believed to be self-fining, and hence requires no artificial clarification either in the vat or cask. Hard water is also much to be preferred to soft in brewing stock beers; since by its rendering the albuminous matters contained in the mash insoluble, it prevents the fermentation to which these would otherwise give rise, and so assists in the preservation of the beer, and in keeping it free from acidity.

Continental brewers, however, who do not brew beverages intended to be kept for any time, on the contrary, employ a soft water, by which means the albuminous substances contained in the malt are rendered soluble, and become diffused

throughout the beer, and possibly add in some measure to its nutritive qualities. Hard waters are said to have the property, over soft ones, of enabling the beer to retain more saccharine matter, and hence to improve its flavour and to give it more body. The ales of Burton are pre-eminent for their excellent quality and keeping properties. In the neighbourhood of Burton there are extensive beds of new red sandstone and gypsum, by sinking wells into which the Burton brewers obtain the water from which they make their beers.

The whole of the water used in the Burton breweries is obtained from wells, and not from the river Trent, as was at one time erroneously supposed. From the subjoined analysis of Burton and other well-known brewing waters, it will be seen that they are all very hard, and contain, besides other salts, a very large quantity of calcic sulphate or gypsum.

Analyses of some well-known Brewing Waters.

	Burton.	Newark.	Well Park. Glasgow.	Stratford-on-Avon.
	Grains per Imperial Gallon.			
Sodium Chloride	10·12	1·96	2·40	6·02
Sodium Sulphate	—	1·89	8·70	—
Potassium Sulphate	7·65	0·65		1·20
Calcium Sulphate	18·96	16·49	7·20	35·89
Magnesium Sulphate	9·95	7·40	1·50	49·02
Calcium Carbonate	15·51	11·06	8·00	21·42
Magnesium Carbonate	1·70	—		1·15
Ferric Carbonate	0·60	—	—	—
Ferric Oxide	—	1·82	0·10	traces
Alumina and Phosphates	—			
Silica	0·79	0·54	0·70	0·49
Alkaline Nitrates	—	1·91	0·30	6·26
Organic Water	—	—	—	
	65·28	43·72	28·90	121·45

It is the practice of some brewers to artificially harden their water-supply; a factitious Burton water may be obtained by adding sulphate of lime to any soft water, in the

proportion stated in the above analyses; this is effected either by adding sulphate of lime crystals to the hot water just before mashing, or by causing the whole of the water-supply required for brewing, to percolate through some crushed gypsum placed in a barrel or suitable vessel; in this way 20 to 30 grains per gallon of calcium sulphate may be easily added to a brewing water.

Dr. C. Graham is of opinion that, although the properties of the Burton well waters are very greatly due to the large quantity of sulphate of lime contained in them, the chlorides of sodium and calcium are also important constituents.

MALT

Is the name given to grain which has been allowed to germinate, the vital process being subsequently stopped by the sudden application of heat. Any kind of grain, such as barley, wheat, oats, maize, &c., may be malted, but the first-named is the grain usually employed for this purpose. The structure, and especially the firmness, of the husk, make barley better suited to undergo the malting processes than other cereals, but wheat and maize are sometimes malted in this country. The germination of barley, and also of all other seeds, produces certain changes in the chemical composition of the grain; the nitrogenous or albuminoid constituents are rendered more soluble, and a peculiar substance, called diastase, is gradually produced. At the same time the amylaceous constituents of the grain are also considerably modified, both physically and chemically, as there is a partial conversion of the starch into dextrine and sugar. The extent and nature of these changes is seen by reference to the following analysis of barley and malt by Dr. Lermer, who found that 100 parts by weight of dry barley yielded 88·81 parts by weight of dry malt, the

difference being accounted for by loss during the malting process, and particularly by the removing of the rootlets.

	100 parts of Dry Barley contain		88·81 parts of Dry Malt contain		100 parts of Dry Malt contain
Starch	63·43	...	48·86	...	55·02
Proteic bodies (flesh-forming substances)	16·25	...	15·99	...	18·00
Dextrine	6·63	...	6·86	...	7·72
Sugar	—	...	2·03	...	2·28
Fatty matters	3·08	...	2·50	...	2·82
Cellulose	7·10	...	7·31	...	8·23
Other substances	1·11	...	3·16	...	3·56
Ash	2·40	...	2·10	...	2·37
	100·00		88·81		100·00

In selecting barley, the maltster seeks for grain possessing a uniform yellow colour, with a thin but wrinkled husk, enclosing a crisp farinaceous kernel. As a rule, the heaviest barleys are the best, and preference is given to those grown on light and loamy soils. Barley that has been over-heated in the stack, or become "mow-burnt," as it is called, or such as contains many mouldy or broken grains, is altogether unsuited for malting. The malt-tax which existed for many years, and was only removed in 1880, was levied equally on all qualities of barley; so there was a tendency to malt only such barleys as would yield a high extract in the brewers' hands; but now some of the lighter and cheaper qualities of barley might probably be used for malting purposes with economy and success. The four successive stages in the process of malting are steeping, couching, flooring, and kiln-drying; but these operations, or some of them, have either originated or been greatly influenced by the fiscal regulations involved in the existence of a malt-tax. The following is a brief *résumé* of these four stages of malting:—

1. **Steeping or Moistening.**—The grain is placed in a large wooden or stone cistern, and sufficient water run in to

cover it. Here it remains for a period of from 40 to 60 hours, depending on the temperature, or until it becomes soft enough to be easily pierced with a needle, or crushed between the thumb and finger without yielding a milky juice. While in steep the grain swells, increasing nearly one-fifth in bulk, and about 50 per cent. in weight. The water is then drained off, and the grain is ready for the next operation.

2. **Couching or Germinating.**—From the cistern the swollen barley is thrown out into the couch-frame to the depth of from 14 or 20 inches, where heat is generated and germination induced. Here it is allowed to remain for from 20 to 30 hours, according to the state of the weather, until the acrospire or plumule shoots forth. Were the grain to remain long in the couch, particularly in warm weather, it would be either unduly forced or turn sour. Whilst in couch it rises in temperature about 15 degrees, and gives off some of its extra moisture. This is called sweating, and as the rootlets now begin to shoot out, means must be taken to check the germination.

3. **Flooring or Regulating.**—This consists in spreading the heated barley on the floor at different depths, according as it is required to increase or retard germination. During this stage of the operation the art of the maltster may be properly said to commence, as now all his judgment is brought into requisition. The grain must be turned three or four times a day, and at each turning the layer is spread out more and more, until it is reduced to the depth of about three or four inches. The chief object to be attained by this operation is a regular germination of the grain.

4. **Kiln-drying.**—The sprouted barley is next spread in a thin layer on the malt kiln, and heat applied. The temperature to which the kiln is raised varies according to the purpose for which the malt is required, the difference between

pale, amber, and brown malt depending solely on the degree of heat to which each has been subjected, and the manner in which the heat has been applied. If the malt were not kiln-dried it would not keep, but would become mouldy. By the process of drying, the vitality of the seed is destroyed, and it may then be preserved without suffering further change.

Independently of variations of quality, or of the grain from which it is formed, malt is distinguished into varieties depending on the heat of the kiln employed for its desiccation. When dried at a temperature ranging between 90° and 120° Fahr., it constitutes "PALE MALT;" when all the moisture has exhaled, and the heat is raised from 125° to 135°, "YELLOW," or "PALE AMBER MALT," is formed; when the heat ranges between 140° and 160°, the product receives the name of "AMBER MALT"; at 160° to 180°, "AMBER BROWN," or "PALE BROWN MALT," is obtained. ROASTED, PATENT, or BLACK MALT, and CRYSTALLIZED MALT, are prepared by a process similar to that of roasting coffee. The malt is placed in sheet-iron cylinders over a strong fire, and the cylinders made to revolve at the rate of about 20 revolutions per minute if roasted malt is required, or 120 for crystallized malt. In the former case the finished malt has a dark brown colour; in the latter, the interior of the grain becomes dark brown, whilst the husk assumes a pale amber hue. The temperature must never exceed 420°, or the malt will become entirely carbonized.

Although the tax is now entirely removed from malt, and maltsters are absolutely free to conduct their operations in any manner they please, the old methods and system of malting still continue to be followed, so that a malting at the present time is but the counterpart of what it was fifty years ago. This is the more astonishing since maltsters were never tired of inveighing against the malt-tax when it was in existence, and urging the many improvements which were

possible if it were only removed. The malting processes, as conducted in foreign countries, also afford illustrations of the way in which our system might be altered with advantage. The following are a few of the modifications which have been suggested and might be adopted. Instead of steeping the barley 40 hours, as was compulsory under the late fiscal regulations, a longer or shorter period might be devoted to this stage according to the character of the barley employed, and according to the softness or hardness of the water, and the atmospheric conditions. Then the "couch," which was originated solely in the interests of the revenue, might be altogether dispensed with, and the germinating process might be initiated by allowing the grain to remain slacked in a heap, the necessary moisture being regulated by judicious sprinkling. As the germinating stages of malting depend upon a proper supply of moisture, heat and air, various plans have been contrived for conducting the operations by mechanical means, thus dispensing almost entirely with hand labour. One of the first and best known of these systems of mechanical malting is that invented by M. Golland, and called by him the *pneumatic system.* According to this, the steeped barley is placed in layers of from 20 to 30 inches in thickness on the perforated floor of a germinating chamber; a current of air is made to pass through the moist barley as required, escaping through the perforations. The air previously passes through a large coke filter, kept continually moist by water trickling down through it; when necessary, the air is also cooled by placing ice in this coke filter; the air is drawn through the filter and forced through the germinating floor by means of a powerful fan. The principal feature in this system is the continuous passing of cool moist air through thick layers of barley, which not only keeps down the temperature, which in the ordinary system has to be done by keeping

skilled workmen to turn over the floors and keep them thin, but keeps the barley at a uniform temperature from the bottom to the top of the chambers, as well as maintains just the right degree of humidity. This pneumatic system of malting offers advantages on the score of economy, for skilled workmen can be dispensed with, and there is a great saving in the area, and consequently the cost, of buildings; another advantage is, that much less grain is crushed and injured by the workmen's feet, for most of the turning is dispensed with, as it is only necessary to prevent the rootlets from growing into the perforations in the floor. This system of malting has been practically adopted in a few of our large maltings, but still most of our maltsters seem to prefer to work upon the old-fashioned and more primitive plan. Other systems of mechanical malting have also been proposed, in which the germinating grain is kept in a slow but regular movement by being placed in a perforated revolving cylinder, the necessary supply of air and moisture being also maintained by suitable inlets, and the temperature of the whole apparatus being regulated with great exactness. There is also very great scope for improvements in the kiln-drying of malt. In England it is the usual custom to place the moist malt on a kiln with one floor only; this floor is made of perforated tiles, or iron plates, or wire netting, and the malt is spread over it in a layer some 8, 10, or 12 inches in thickness; the products of combustion from the furnace, in which anthracite or other smokeless fuel is consumed, are made to pass through a thick layer of moist grain, which is thus kept at a high temperature for a considerable period of time—in some cases for three or four days. The German maltster proceeds on an altogether different plan. He constructs his kiln with two floors; the moist malt is first placed in a thin layer on the upper floor of the kiln, where a temperature of only about 100° Fahr. drives off nearly all the moisture

in about an hour; the comparatively dry malt then passes on to the lower floor, where it is heated to about 170° Fahr., and acquires the pleasant empyreumatic flavour peculiar to good malt; in this way the kiln-drying is completed in a few hours. These double-floor kilns are a great improvement on our old-fashioned plan, and will, no doubt, soon come into general use in this country. In the meantime, FREE'S patent malt-kiln, which has a large drying area and regulates the current of hot air, is a step in the right direction.

Good malt has an agreeable smell and a sweet taste. It is friable, and when broken discloses a floury kernel. Its husk is thin, clean, and unshrivelled in appearance, and the acrospire is seen extending up the back of the grain, beneath the skin. The admixture of unmalted with malted grain may be discovered, and roughly estimated, by throwing a little into water; malt floats on water, but barley sinks in it. The only certain method, however, of determining the value of malt is to ascertain the amount of soluble matter which it contains, by direct experiment. This varies from 62 to 70 per cent., and for good malt is never less than 66 to 67 per cent. If we assume the quarter of malt at 324 lbs., and the average quantity of soluble matter at 66 per cent., then the total weight of soluble matter will be fully $313\frac{3}{4}$ lbs. per quarter; but as this, "in taking on the form of gum and sugar" during the process of mashing, "chemically combines with the elements of water, so the extract, if evaporated to dryness, would reach very nearly 231 lbs.; and this reduced to the basis of a barrel of 36 gallons, becomes, in the language of the brewer, 87 lbs. per barrel, which, however, merely means that the wort from a quarter of malt, if evaporated down to the bulk of a barrel of 36 gallons, would weigh 87 lbs. more than a barrel of water." *

* Ure.

Testing Malts.—Although a practical maltster and brewer may, by simply inspecting it, be a good judge of the quality of a sample of malt, experience has proved that an exact chemical examination is also of great value, and many brewers, therefore, adopt some methods of analysing malt. The moisture is determined as follows:—A small quantity of the sample being ground in a coffee or pepper-mill, 100 grains are accurately weighed, and dried by exposure for about one hour at the temperature of boiling water. The loss in weight, in grains, indicates the quantity of moisture per cent. This, in good malt, should not exceed $6\frac{1}{2}$ grains.

The following is a method of determining the amount of extract yielded by a malt:—100 grammes (= 1,543 grains) are ground fine in a coffee mill; 433 grammes (= 6,681 grains) of water are placed in a tared flask; the malt is then added and thoroughly mixed with the water; the flask containing the mixture is then heated in a water-bath to a temperature of from 162° to 167° Fahr., taking care not to exceed the latter limit, and shaking up the mass from time to time; the flask is then covered up and allowed to stand for one hour. In this way a miniature mash is made by which all the soluble constituents of the malt are extracted, and at the same time the starch of the grain is converted into dextrine and sugar. If the liquid soon becomes bright, if the grains fall quickly and completely to the bottom of the flask, and if the liquid assume a dark and black appearance by reflected light, there are signs that the malt has been well germinated and is good in quality, and that the operations of brewing with it will proceed in a satisfactory manner. To determine the amount of the extract, a portion of the wort is transferred to a test-glass, and its gravity taken by means of the saccharometer. The percentage of extract can then be ascertained by dividing the degrees of

gravity by 3·75. The entire mash weighed 533 grammes (=8,224 grains), and we may reckon that the dry grains will weigh on the average 33 grammes (=509 grains). The weight of the wort will, therefore, be 500 grammes (=7,715 grains); it is, therefore, only necessary to multiply the weight of extract as determined by the saccharometer by 5, to obtain the weight of extract in 100 grammes of malt. Precautions must, of course, be taken to prevent loss of water by evaporation during mashing, and if any occur, it can be ascertained by weighing the flask, with its contents, prior to pouring off the small sample. A very important point in testing malts is to ascertain the acidity; this can be done by neutralizing the whole of the extract from the 100 grammes of malt with a standard solution of ammonia, and by a simple calculation the percentage of acid, expressed as lactic acid, can be determined. In addition to the chemical tests already given, it is found useful in judging malts to weigh 100 corns; as a rule, the best malts weigh the heaviest; from 50 to 60 grains may be taken as the average weights of sound malts made from English or good foreign barley. It is also convenient to make a numerical analysis of 100 corns of the malt by dividing them into separate heaps, according to the length to which the acrospire or internal plumule has grown; our brewers consider a $\frac{3}{4}$-grown acrospire to be the best, but the greatest importance is attached to the evenness of the growth, and the presence of any overgrown acrospire is a sure sign of deficient extract, whilst mouldy and damaged corns indicate unsoundness.

HOPS.

The hops of commerce are the strobiles or catkins of the hop plant; these strobiles are covered with a resinous

yellow powder, sometimes called *lupulin*, which contains the bitter principle. The following analysis will show the average composition of well-dried hops:—

Scales	78·1
Yellow Powder	17·0
Moisture	4·6

	Scales.		Powder.
Volatile Oil	—	...	0·1
Bitter Principle	4·7	...	3·0
Tannic Acid	1·6	...	0·7
Resinous Matter	2·0	...	2·9
Gummy Matter	5·8	...	1·3
Cellular Tissue	64·0	...	9·0
	78·1		17·0
Aqueous Extract	12·1		4·9

The following analyses of twelve samples of different kinds of hops, made by Mr. W. C. Porter, F.C.S., will show the difference between each kind of hops, and especially between those dried upon Mr. Hopkins's improved kiln, where the temperature is not allowed to exceed 100° Fahr.

Nos.	Name of Hops.	Quality.	Amount of Moisture.	Amount of Resin, Oil, and Bitter Principle.
1	Worcester Dried on Hopkins's Kilns	Fine	4·02	14·98
2	Spält Dried on Hopkins's Kilns	Fine	6·96	14·08
3	East Kent	Fine	6·15	13·60
4	Worcester	Medium	8·10	13·35
5	Kent	Medium	8·20	13·27
6	Sussex	Medium	7·05	11·75
7	Bavaria	Medium	9·97	13·08
8	American	Medium	7·87	12·63
9	Sussex	Low	8·55	9·95
10	Sussex	Low	9·87	9·23
11	Poperinghe (Belgium)	Low	10·25	9·25
12	Worcester	Low	9·20	8·80

The bitter principle and the volatile oil are the constituents upon which the value of hops depend, and as they are found chiefly in the yellow powder, preference is given by brewers to samples containing a large proportion of this powder. The tannic acid of the hops also plays an important part in the brewing process, for it acts by removing a portion of the albuminous constituents of the wort during the boiling.

In the choice of hops care should be taken to select those that have large cones or strobiles, that are the most odorous and most free from leaves, stems, scaly fragments, and sticks, and which, when rubbed between the hands, impart, in the greatest degree, a yellowish tint and glutinous feeling to the skin. The tightness with which they are packed should also be noticed; as, without being very firmly pressed together, and quite solid, they soon spoil by keeping. The finest flavoured hops are the "GOLDINGS," grown chiefly in middle and east Kent; the "WHITEBINES" of Farnham and Canterbury; and the WORCESTER HOPS grown on the red soils of the vale of the Severn. These are principally employed for the finer class of ales. Mid-Kent and Sussex hops are also used for ale, but have an inferior colour and flavour. The best hops are packed in sacks of fine canvas, termed "pockets," weighing from $1\frac{1}{4}$ cwt. to $1\frac{3}{4}$ cwt. each, and are mostly purchased by the ale brewers, while the inferior qualities are taken by the porter brewers. When hops are older than of last season's growth they are termed "yearlings;" when of the second season's growth, "old;" and when three years, or older, "old olds."

SUGAR.

Since 1847 it has been legal to use sugar as a substitute for malt in brewing, and many brewers have largely availed themselves of this privilege. During the last years of the

malt-tax, sugar paid a duty of 11*s.* 6*d.* per cwt., which was deemed the equivalent of the tax; but now brewers pay duty according to the yield of extract. There are several varieties of sugar in use, including the different kinds of raw sugar, some refined sugars, glucose or starch sugars, invert sugars, saccharums, &c. Refined cane-sugars are, as as rule, too expensive for brewers' use, but some of the cheaper concretes and jaggerys are largely employed; but as many of these contain a considerable percentage of mineral matter—often from 5 to 10 per cent.—they should be used with caution. Many brewers have a prejudice against all forms of cane-sugars, founded no doubt on the fact that cane-sugar itself is not fermentable, until it is inverted or converted into glucose, and this inversion or conversion, which takes place under the influence of the yeast, tends to weaken its fermentative power. For this reason specially prepared sugars, called saccharums, composed of glucose and inverted cane-sugars, are now largely manufactured in this country for brewers' use, and yield excellent beer when used in moderate quantities in conjunction with malt. Glucose or starch sugar is also extensively employed in brewing; this kind of sugar is made from rice, maize, sago, or other cereals, by converting the starch into glucose or grape-sugar by the aid of dilute sulphuric acid and subsequently removing the acid by means of carbonate of lime. Large manufactories now exist in this country for making this kind of sugar for brewers, and large quantities of this sugar are also imported from the Continent and America. A few years since MESSRS. VALENTIN and O'SULLIVAN invented a process for manufacturing a particular kind of sugar, which they called dextrin-maltose, and which was prepared in a similar manner to glucose, but the conversion was stopped at a point before the whole became glucose; this dextrin-maltose, as its name implies, was a combination of one part

of dextrin with two parts of maltose—the sugar formed by the action of malt extract on starch, and it was considered that this combination was the same as the brewer usually obtained in his ordinary mashing operation with malt. The production of dextrin-maltose has not, however, yet been carried out on an extensive manufacturing scale. Glucose is only half as sweet as ordinary cane-sugar, and beers made with it are generally considered to be thin in flavour; brewers, therefore, rather give the preference to "invert" sugars, which are almost as sweet as cane-sugar, and give a full or "round" flavour to beers brewed with them. According to the Brewers' Returns collected by the Excise, 1,125,342 cwts. of sugar were used in brewing during 1881.

RAW GRAIN.

Since October, 1880, brewers have been at liberty to use any wholesome material as a substitute for malt, and many have availed themselves of this privilege. In this way unmalted grain, such as barley, maize, rice, &c., is now extensively employed in conjunction with malt; in fact, any substance which contains starch or other constituents capable of being converted into soluble saccharine extract, and which is at the same time free from constituents calculated to injure the wholesomeness, flavour, and keeping qualities of the beer brewed with it, may now be used in brewing; in practice, however, the cereals just mentioned are the only ones that have at present been employed. There are two distinct ways in which the starch of raw grain may be saccharified and rendered soluble—namely, by the action of dilute acids, and by the agency of malt extract; the first-named necessitates the employment of special plant and apparatus altogether different to that usually found in existing breweries, whilst the last-named system of conversion

can be carried on in the ordinary utensils of a brewery, or at all events with but few modifications, and therefore this system naturally finds most favour with brewers. The conversion of starch into sugar by dilute acids, takes place with great facility under increased pressures, and therefore it has been suggested by Manbré, Johnson, and others, that the raw grain should be placed with the requisite quantity of water in suitably constructed vessels called converters, and the requisite quantity of acid having been run in and intimately mixed with the material, heat and pressure are applied until the whole of the starch is converted. The acid usually used is sulphuric, but oxalic acid has also been suggested; but of course its poisonous character is a great objection. After the conversion, the acid is removed by adding excess of carbonate of lime and the syrup or wort is purified by filtration and decolorized if necessary, by passing it through beds of animal charcoal, and it is then fit to be mixed with the ordinary malt wort. As we have already stated, the plan of converting raw grain by malt-extract is much preferred to the chemical method we have just described. When malt alone is used as the converting agent, the raw grain should be submitted to a preliminary treatment; in the case of maize especially, the husk and the germs should be removed by a special system of grinding or kibbling, for in the husk and the germ are found certain oily and albuminous substances, which greatly interfere with the good flavour and keeping qualities of beer brewed from this grain; a preparation called "germless maize" is now supplied to brewers, which is an excellent and economical brewing material. Raw, or more correctly unmalted, grain ought never to be used without being submitted to a preliminary treatment. Continental brewers, who use unmalted grain, are in the habit of first steeping it for a short time to remove any unpleasant flavour, which is chiefly

found in the husk, and then it is kiln-dried for a time, by which some of the pleasant empyreumatic flavours peculiar to good malt are developed. Acting on this experience, manufacturers in this country now prepare for our brewers' use such preparations as "gelatinized" or "peptonized" barley, rice, maize, &c., "torrefied" grain, and such like. Raw grain, prepared in the ways we have indicated, when ground to a suitable degree of fineness, can then be mashed with malt in the ordinary mash-tun, and the whole of the extract can be obtained with ordinary care; in some cases it is found advisable to enclose the mash-tun with a steam jacket, so that the temperature of the mash can be controlled or sustained, and it is always necessary to have internal rakes in the mash-tun to prevent "balling." The following analysis by PILLITZ, of barley, rice, and maize, will be found useful in comparing the values of these three cereals as brewing materials:—

		Barley.		Rice.		Maize.	
		Air-dried.	Dried at 257° F.	Air-dried.	Dried at 257° F.	Air-dried.	Dried at 257° F.
Moisture		13·88	—	12·51	—	13·89	—
Starch		54·07	62·65	74·88	85·41	62·69	72·27
Insoluble Ash		1·07	1·23	0·39	0·45	0·33	0·38
Fatty Matters		2·66	3·08	0·78	0·90	4·36	5·03
Cellulose		7·76	8·88	0·76	0·87	4·19	4·82
Insoluble Albuminoids		12·43	14·28	8·78	10·01	8·63	9·95
Dextrine	Soluble in Water.	1·70	1·96	1·11	1·27	0·76	0·83
Sugar	Soluble in Water.	2·43	2·71	traces	traces	1·38	1·59
Soluble Albuminoids	Soluble in Water.	1·77	2·05	0·41	0·46	1·87	2·16
Soluble Ash	Soluble in Water.	1·26	1·45	0.45	0·51	1·15	1·32
Extractive Matter	Soluble in Water.	1·50	1·71	0·11	0·12	1·43	1·65
		100·53	100·00	100·18	100·00	100·68	100·00

The yield in extract of these materials depends upon the constituents soluble in water, but chiefly on the percentage

of starch; and on comparing them with malt, it will be seen they are all capable of yielding a richer extract. The market prices of these cereals, although subject to considerable fluctuation, are always lower than malt, and therefore there must be considerable economy in their use; of the three cereals referred to, rice, at the present time, is by far the cheapest. In all calculations of this nature, the quality of the resulting beer must be taken into consideration, and it can scarcely yet be claimed for these raw-grain beers that they are equal in flavour to those which are prepared entirely from malt.

ARRANGEMENT OF A BREWERY.

Assuming a suitable site for a brewery has been chosen, due regard having been taken to the means of communication both for conveying the raw materials to, and the finished product from, the premises, the elements of success still depend to a great extent upon the internal arrangement of the brewery itself. We must premise, however, that it is absolutely essential to have a plentiful supply of water suitable for brewing, both as regards chemical composition, for that actually used in mashing; and as regards temperature, for that required for cooling purposes. The following description of a medium-sized establishment, covering about 140 feet square, is typical of the arrangements met with in a well-appointed modern brewery:—

"On one side of this square is placed the main building of the brewery, about 30 feet wide inside; on the remaining sides of the square are erected stabling for the horses, cask-sheds, cooperage, boiler-house, coal-store, cask cleaning shed, and the brewery offices adjoining the entrance gates, leaving a large internal yard, or quadrangle. The main building is in three stories, about 12 feet from floor to floor, the roof plate being about 7 feet above the second floor. A

portion of the building is roofed by the water-tank, about 30 feet square and 7 feet deep. The remainder of the building is covered with a slated roof, with iron framework of simple construction, with ventilating louvres at the apex throughout the entire length of the roof. The portion of the second floor immediately below the water-tank, called the malt-floor, contains a malt store about 20 feet long by the full width of the building, with an external door and crane; adjacent to this is the grist-box, and on the other side, the hop store, of convenient side. Next to the grist-box is the liquor-boiler, a wrought-iron receptacle 15 feet square and 7 feet deep, of a capacity of about 275 barrels, or 10,000 gallons. On this floor also are placed two coppers, hemispherical in form, each of about 2,000 gallons, fitted with steam jackets and heated with high-pressure steam. The remainder of this floor is occupied by the coolers, formed of iron plates, carried upon wood joists, and laid with a uniform fall of not less than 1 in 250. Copper is the best material for constructing the coolers, but it is more expensive. Four horizontal fans are placed equidistantly in the centre line of the coolers, driven at a speed of 200 revolutions per minute, from the shafting below the floor, the walls being pierced on both sides with louvre ventilators. The liquor-boiler above alluded to, is heated by leading the exhaust steam-pipe through it in a circuitous route. We now come to the first-floor, which contains at one end a small room for the malt mill, partitioned off immediately below the malt store; from this mill an elevator conveys the grist to the grist-box above. Under the liquor-boiler and grist-box are placed the mash-tuns, in such a brewery as we are now describing, two in number, each 12 feet diameter by 3 feet 6 inches deep, with a Steele's mashing machine for intimately mixing the grist and water fixed between them.

The rest of this floor is occupied by the fermenting-room, having, say, eighteen fermenting squares, each about 7 feet 6 inches square, by 4 feet 6 inches deep, nine on each side. These squares are constructed of white pine, and fitted with copper coils for the circulation of hop and water used in attemperating the fermenting wort. On the ground-floor are placed the engine-room and carpenter's shop. Next to these are the underbacks, being large square wooden vessels, having a capacity of about 2,000 gallons each. The wort is raised from these backs to the coolers by means of pumps. The space on the ground-floor, under the fermenting-room, is used as a cellar. A line of shafting extends the whole length of the brewery, fixed below the second-floor for the purpose of giving motion to the fans on the cooling-floor and other parts where power is required." Ventilation should be carefully studied throughout the brewery; all parts should have plentiful supplies of fresh air, except the malt and hop stores, which should be closely partitioned off, and lined with boarding.

PROCESSES OF BREWING.

Having referred to the different materials used in the manufacture of beer, and also given a general description of the arrangement of a brewery, we will now describe the processes of brewing; these may be conveniently divided into four main stages—viz., mashing, boiling, cooling, and fermenting, with the subsidiary processes of cleansing, storing, ripening, and fining.

1. **Mashing**:—The ground or bruised malt placed in the mash-tun is macerated for some time in hot water, and the infusion (*wort*) drawn off from a hole in the bottom, over which a strainer or false bottom is placed, to prevent the malt passing out along with the liquor.

During the process of mashing a peculiar principle contained in the malt, called diastase, reacts upon the starch with which it is associated, and converts it into grape sugar. The more completely this conversion is effected, the richer will be the resulting wort in sugar or "*saccharine*," and the stronger and more alcoholic the beer produced by its fermentation. It is, therefore, a desideratum with the brewer to mash at the temperature which most fully promotes this important object. The best temperature for this purpose ranges between 150° and 170° Fahr. When more than one mash is made, the first should be something lower than the first-named temperature; the second may be from 175° to 185°; and the third as high as 200° Fahr.

If the first mashing has been rightly conducted, the whole of the starch will be converted into sugar, and the action of the second and third mashings is merely to wash out any of the remaining saccharine matter still existing in the crushed grain.

In practice, as soon as the water in the copper acquires the temperature of 170°, 45 galls. are run into the mash-tun for every quarter of mashed malt to be mashed. The whole is now thoroughly mixed with the mash liquor, by means of oars, or machinery, the agitation (*mashing*) being continued for 30 or 40 minutes, when 36 galls. more water per quarter from the copper are added, and the whole again well agitated, as before. The mash-tun is now closely covered up, and the mash allowed to repose for about two hours, in order that the diastase may exert its saccharifying power upon the unconverted starch of the malt. At the end of this time the tap is set, and the wort run into the "underback." The second mash is then made with about 60 galls. of water per quarter, at 185° Fahr., and the whole process repeated as before. After an hour the liquor

is drawn off, and the malt drained ready for the third mash. This time only 35 galls. of water per quarter are added at 200° Fahr., and the whole is seldom allowed to stand longer than half an hour. It is then run off, and the malt allowed to drain as dry as possible.

In some cases the worts of the first and second mashes only are used for strong beer; that of the third mashing being kept for table-beer, or as liquor to mash a fresh quantity of malt.

Pale malt and mixtures of malt and raw grain should be mashed for a longer time, and at a somewhat lower temperature than brown or high-dried malt.

Instead of making second and third mashes as above described, it has long been the practice in Scotland, and is now becoming common in England, to sprinkle the surface of the grains in the mash-tun with water, at or about the temperature of 180° Fahr., by means of a simple revolving instrument termed a "sparger," and to let the liquor drain through the goods and run off by the tap with the last portions of the first wort. By this means the whole surface of the grain is continuously and regularly sprinkled with hot water.

When sugar is used it may be either mixed with the malt in the mash-tun, at the time of mashing, or put into the underback, just before setting tap and the hot wort run upon it. The proportions of malt and sugar vary according to the quality of the latter; but, on an average, 200 lbs. of good raw sugar may be taken as the equivalent of a quarter of malt; according to the Excise, 28 lbs. of sugar is deemed equivalent to 42 lbs. of malt.

Such is the infusion process of mashing, as carried out in this country, the temperatures and proportion of malt to water being varied according to the views of individual brewers, and depending also upon the quality of the mate-

rials used, and the requirements of the public taste in different districts. On the Continent, and in Germany especially, an entirely different system is adopted, as will be seen by the following description, by Dr. Graham, of the Bavarian method of mashing followed in the brewing of lager beer :—

"In the old Bavarian process, the ground malt is thrown into the mash-tun, in which there is some cold water, here it remains for two hours; meanwhile the remainder of the water is boiled in the copper, and is then run into the mash-tun in two successive portions under the plates, the rakes of course going. The temperature is thus raised to 95° to 100° Fahr. The first Dickmaisch, as it is called, is then run off and boiled for about half-an-hour. So soon as the solids of the Dickmaisch in the copper come up to the surface by the brisk boiling, a portion is run off into the tun under the plates, the rakes going throughout; in this way the temperature is raised to about 122° Fahr. After this, the second Dickmaisch is pumped into the copper, and is boiled for three-quarters of an hour to an hour. This is then run into the tun in two successive portions, so as to raise the temperature to 140° Fahr. After a quarter of an hour's rest, tap is set, and the greater part of the Lautermaisch, or clear wort, as it is now called, is run into the copper and heated to boiling; it is kept boiling for a quarter of an hour, and is then run back to the mash-tun, whereby the temperature is raised to 161° to 167° Fahr. This is now left at rest for an hour to an hour and a half. Then the wort is run off; the first part being cloudy, is run on to the top of the malt again. So soon as it flows bright, it is run into the copper as fast as it drains from the malt. The saccharine matter adhering to the mash in the tun is washed out of it by a second mash, as is often the method with us. Some even use a third mash to remove all the saccharine material."

Chemical Changes during Mashing.—For many years it was assumed that the changes which took place in the brewer's mash-tun consisted simply in the conversion of the insoluble starch of the grain into dextrine and grape-sugar, or dextrose, both of which are soluble. In 1833 two French chemists, Messrs. Payen and Persoz, discovered that malt contained a peculiar substance, called diastase, which possessed the remarkable property of converting starch into sugar, and so great was the power of this substance in this respect that one part was considered to be sufficient to convert 2,000 parts into sugar. Subsequent researches of Musculus, Dubrunfaut, and especially of our countrymen, O'Sullivan, Brown and Heron, and Graham, have thrown much fresh light on the chemical changes which take place during mashing, and we now have reason to believe that the conversion of starch is due to a process of hydration, brought about by the agency of a number of albuminous bodies, which have been described as "soluble ferments," diastase being typical of this class of bodies. The kind of sugar which is the principal product of the action of these soluble ferments on starch is the one called Maltose ($C_{12}H_{22}O_{11}$), which has been fully examined by O'Sullivan; it is a white substance, soluble in water, but only slightly soluble in alcohol. Its reducing power, as regards Fehling's solution, is only 66 (O'Sullivan), or 61 (Brown and Heron), whilst dextrose is 100, and cane-sugar is *nil;* maltose has a rotatory power on polarized light equal to $+ 150°$. When submitted to the action of dilute acids, maltose yields dextrose as the ultimate product of the hydration; on the other hand, malt extract or diastase has no action upon maltose; even the acid, always present in malt in small amount, is unable to effect any change in this respect. Maltose is a much more stable body than cane-sugar, which is readily inverted by malt-extract, even at low temperatures. According to

O'Sullivan, the action of malt-extract on starch is varied by the surrounding circumstances, and he is of opinion that at least four distinct reactions are possible, involving in each case an absorption and assimilation of the elements of water. The formation of these hydration products of starch are illustrated in the following table :—

	Starch.			Maltose.		α Dextrine.
1.	$C_{72}H_{120}O_{60}$	$+ H_2O$	=	$C_{12}H_{22}O_{11}$	+	$C_{60}H_{100}O_{50}$
						β Dextrine i.
2.	$C_{72}H_{120}O_{60}$	$+ 2H_2O$	=	$2C_{12}H_{22}O_{11}$	+	$C_{48}H_{80}O_{40}$
						β Dextrine ii.
3.	$C_{72}H_{120}O_{60}$	$+ 3H_2O$	=	$3C_{12}H_{22}O_{11}$	+	$C_{36}H_{60}O_{30}$
						β Dextrine iii.
4.	$C_{72}H_{120}O_{60}$	$+ 4H_2O$	=	$4C_{12}H_{22}O_{11}$	+	$C_{24}H_{40}O_{20}$

Brown and Heron have also investigated this subject, and as the result of their researches they are of opinion that at least nine distinct dextrines are formed during the different stages of the conversion of starch into maltose. We are indebted to Dr. Charles Graham, who has made a special study of the changes which take place during the mashing process, for a series of experiments upon the influences of time, mass, temperature, and other factors upon the composition of the resulting wort; his main results are given in the following five tables, quoted from a published lecture on lager beer, delivered before the Society of Chemical Industry :—

No. I.—*Influence of Initial Heat.*

Ratio of Malt to Water 1 : 10. Time, 2 hours.

	Temperature. Deg. Fahrenheit.	Maltose.	Dextrine.	Total Sugars.
Malt No. 1 .	150	47·46	10·70	58·16
	160	43·50	13·42	56·92
	170	32·17	17·61	49·78
Malt No. 2 .	140	52·81	12·08	64·89
	150	48·61	13·83	62·44
	160	41·65	17·42	59·07
	170	30·24	25·09	55·33

No. I.—*continued.*

Ratio of Malt to Water 1 : 10. Time, two hours.

	Temperature. Deg. Fahrenheit.	Maltose.	Dextrine.	Total Sugars.
Malt No. 3	140	51·36	10·60	61·96
	150	45·30	14·35	59·65
	160	39·90	18·06	57·96

The malt was mixed with cold water and the temperature raised in thirty minutes to the various heats given; and the infusion process then conducted for two hours at the respective heats.

No. II.—*Influence of Quantity of Water.*

Malt 100. Temperature 140 deg. Fahrenheit. Time, two hours.

	Quantity of Water.	Maltose.	Dextrine.	Total Sugars.
Malt No. 1	1,000	53·56	11·39	64·95
	500	49·99	12·92	62·91
	200	49·00	13·88	62·88
	100	46·80	15·08	61·88
Malt No. 2	1,000	52 81	12·08	64·89
	500	53·56	9·82	63·38

No. III.—*Influence of Time.*

Malt 100. Water 1,000. Temperature 145 deg. Fahrenheit.

	Duration of Mash.	Maltose.	Dextrine.	Total Sugars.
Malt No. 1	30 min.	48·60	14·61	63 21
	1 hour	52·35	12·26	64·61
	2 ,,	53·56	11·39	64·95
	3 ,,	54·60	11·05	64·65
	7 ,,	61·47	3·53	65·00
Malt No. 2	30 min.	49·99	14·98	64·97
	1 hour	53·56	13·43	66·99
	2 ,,	57·69	10·76	68·45
	3 ,,	59·52	8·71	68·23
	5 ,,	61·47	7·91	69·38
Malt No. 3	30 min.	47·46	13·89	61·35
	1 hour	48·69	14·27	62·96
	2 ,,	52·81	12·08	64·89
	4 ,,	54·34	10·67	65·01
	6 ,,	57·24	8·67	65·91

No. IV.—*Influence of Diastase.*

Malt or substitute, 100. Water, 1,000. Time, two hours. Temperature, 145 degrees Fahrenheit.

	A.				B.			
	Barley 100.	Barley 90. Malt 10.	Barley 80. Malt 20.	Barley 50. Malt 50.	Rice* 25. Malt 75.	Rice 50. Malt 50.	Rice 75. Malt 25.	Malt 100.
Maltose . .	33·33	37·87	41·65	44·64	58·72	60·00	62·49	57·69
Dextrine. .	11·42	15·96	16·96	15·90	7·12	10·97	11·26	1·73
Total Sugars	44·75	53·83	58·61	60·54	65·84	70·97	73·75	59·42

*Rice=72 per cent. starch.

C.

	Raw Barley 50. Malt 50.	Boiled Barley 50. Malt 50.	High Dried Barley 50. Malt 50.	High Dried (Boiled) 50. Malt 50.	Rice Boiled 50. Malt 50.
Maltose . .	47·62	46·15	42·50	41·34	54·15
Dextrine . .	17·38	18·48	22·11	22·48	22·46
Total Sugars.	65·00	64·63	64·61	63·82	76·61

D.

	Raw Barley 25. Malt 75.	Raw Barley 50. Malt 50.	Raw Barley 75. Malt 25.	Boiled Barley 25. Malt 75.	Boiled Barley 50. Malt 50.	Boiled Barley 75. Malt 25.
Maltose . .	57·69	53·56	49·99	53·56	49·99	46·87
Dextrine .	5·65	10·87	15·27	11·89	15·97	19·99
Total Sugars	63·34	64·43	65·26	65·45	65·96	66·86

	High Dried Barley 25. Malt 75.	High Dried 50. Malt 50.	High Dried 75. Malt 25.	High Dried (boiled) 25. Malt 75.	High Dried (boiled) 25. Malt 50.	Boiled High Dried.
Maltose . . .	50·87	48·10	45·11	49·99	46·87	44·11
Dextrine . . .	14·43	17·05	19·88	18·94	19·98	22·07
Total Sugars .	65·30	65·15	64·99	68·93	66·85	66·18

N B.—The malts and barleys in series A, B, C, D were different, though the same for any given series.

No. V.—*Influence of High Kiln Heats on Infusion Products of Malt.*

	80° C.		100° C.		120° C.
Maltose	57·01	...	52·44	...	51·32
Dextrine	14·92	...	18·49	...	19·35
Lactic Acid	0·56	...	0·49	...	0·31
Soluble Albuminoids . . .	2·09	...	1·60	...	1·50
Colouring Matters, ash, &c..	1·49	...	1·38	...	1·32
Total dry solids.	76·07	...	74·40	...	73·80

A careful study of these results will be found of great value to the practical brewer. He will perceive that, by varying the temperatures and duration of the mash, it is possible to control and modify the ratio of the sugar to the dextrine. Thus some brewers limit the time of infusion to one hour, and limit somewhat the quantity of water employed, and in this way obtain a more dextrinous wort; on the other hand, by prolonging the infusion process, and using a fair quantity of water, a wort is obtained richer in maltose, and therefore a more alcoholic ale is then obtained when the attenuation is pushed low enough. Dr. Graham's experiments on the influence of diastase, as given in the fourth table, are of great interest to brewers who use raw grain, whilst the influence of kiln drying, as shown in the last table, proves that malt, kiln dried at very low temperatures, contains more soluble albumenoids, and must therefore have great diastasic power.

When the process of mashing has been properly conducted, the wort should not be turned blue by tincture of iodine. If it turns blue some of the starch has escaped conversion into sugar, and is dissolved in the liquor, and unconverted starch in wort is dangerous from its proneness to decomposition at high temperature, especially when albumenoids are present.

Saccharometer.—This is an instrument similar in prin-

ciple to the common spirit hydrometer, but so weighted and graduated as to adapt it for the indication of the richness of malt-worts in sugar, or saccharine, expressed in pounds per barrel, or the excess of gravity over that of water, the last being taken at 1,000.

Under the Inland Revenue Act of 1880, the Excise denote by the term "gravity" the excess of weight of 1,000 parts of a liquid by volume above the weight of a like volume of distilled water, both taken at 60° Fahr., so that if the specific gravity of a wort be 1045, 1057, 1070, 1090, &c., the gravity is said to be 45, 57, 70, 90, &c. The beer duty is levied on the worts at the rate of *6s. 3d.* per barrel of 36 gallons, at the gravity of 57, so that 1057 specific gravity —that is, 57 degrees of gravity, is said to be the standard gravity of beer worts. Prior to the Act we have referred to coming into operation, brewers were in the habit of denoting the weight of saccharine matter in a barrel (36 gallons) of wort by the expression "pounds per barrel," which means the extra weight expressed in pounds avoirdupois, that 36 gallons of wort, at 62° Fahr., had over the weight of a barrel of distilled water at the same temperature. Although at the present time brewers are compelled, for Excise purposes, to express the strength of their worts in terms of the degrees of gravity, they still, for their own purposes, continue to use saccharometers indicating "pounds per barrel." A "degree of gravity" is $\frac{1}{1000}$th part of the gravity of water, and a "pound per barrel" is $\frac{1}{360}$th part of the gravity of water, so that a "degree of gravity" is to a "pound per barrel" as $\frac{1}{1000}$ to $\frac{1}{360}$; hence by simply multiplying the degrees of gravity by ·36, we ascertain the pounds per barrel, or, *vice versâ*, by dividing the pounds per barrel by ·36, we ascertain the degrees of gravity. Suppose a sample of wort to have a specific gravity of 1057, that is, 57 degrees of gravity, then $57 \times {\cdot}36 = 20{\cdot}52$

pounds per barrel. Again, the strength of a wort is 19·8 pounds per barrel, then $19{\cdot}8 \div 36 = 55$ degrees of gravity—that is, 1055 specific gravity.

2. **Boiling.**—After running into the underback from the mash-tun the wort is next transferred to the copper, and heated to the boiling-point as soon as possible, the object of this expedition being to prevent the formation of acid in the wort, by exposure to the air, before undergoing the changes which take place in the copper. As soon as the boiling of the wort commences the hops are added, and the boiling is continued for about 2 or 2½ hours. A longer boiling is highly objectionable, owing to the extraction of a heavy, resinous bitter from the hop, and the danger of losing the volatile oil upon which the aroma depends. For mild beers the worts are seldom boiled so long; for strong keeping ales, sometimes a little longer. The boiling is known to be completed when the liquor "clears," as it is called, and albuminous flocks sink to the bottom of the copper.

The quantity of hops required by a given measure of malt varies from 2 lbs. to 22 lbs. per quarter, according to the strength or gravity of the wort, the character of the beer intended to be brewed, and the climate which the beer may have to sustain. Export beer requires, as a rule, an exceptionally large amount of hops to enable it to bear, without injury, the heat of the country to which it is shipped. The following are the usual quantities of hops used per quarter of malt :—

Table Beer	2 lbs.
Mild Ale or Porter	4 ,,
Brown Stout	5 ,,
Scotch Ale (best)	5 ,,
Strong Ale (ordinary)	5½ ,,
,, (keeping)	8 ,,
Bitter Ale	10 to 14 ,,
East India Ale (export)	12 ,, 22 ,,

When a strong, coarse hop is used, a less quantity suffices for the same strength brewed, but the flavour is always inferior.

The hops, strained from each wort, are returned into the copper with the following one.

The average loss by evaporation in the process of boiling varies from $\frac{1}{6}$th to $\frac{1}{7}$th of the original bulk of the wort. The gravity increases at the same time in about the ratio of 5 to 4; so that if the gravity be, at first, say 32 lbs. per barrel, it will at the end of the operation have risen to about 40 lbs.

3. **Cooling.**—The wort, under the common system, is "run off" from the copper into the "hop-back," through a strainer which keeps back the hops. It is then pumped into large square shallow vessels called "coolers," where it is freely exposed to a current of air to reduce its temperature as quickly as possible, in order to avoid acidity or "souring." In 6 or 7 hours, or sooner, the temperature should fall to about 60° Fahr. In warm weather the depth of the liquor in the coolers should not exceed 3 or 4 inches; and in cold weather not more than 5 or 6 inches.

The rapid cooling of worts is an important object with the brewer and distiller. On the large scale, the old system in which shallow coolers are employed, with all its numerous inconveniences and accidents, is now for the most part abandoned, being supplanted by the use of a "refrigerator," which is an apparatus so constructed that any hot liquid may be cooled down to within 2° of the temperature of the cold water in a very short space of time. The principle is that of passing the two fluids through very shallow and very long passages, in opposite directions, being essentially that of a "Liebig's condenser" on a gigantic scale. The apparatus may consist of zigzag passages, flattened tubes, or convoluted curves, of any convenient shape, so that they possess little

capacity in one direction, but great breadth and length. A refrigerator, having the passages for the fluids $\frac{1}{8}$th of an inch thick, is said to require a run of about 80 feet to bring the worts down to within 2° of the water. The success of this method is such as to leave nothing more to be desired.

The loss by evaporation and condensation in the coolers varies from 13 to 18 gallons per quarter.

4. **Fermentation.**—The cooled wort is next run into the fermenting tuns or vessels (gyle-tuns). In small brewings these may be casks with one of their heads removed; but under any form they must not be more than $\frac{2}{3}$rds filled. The yeast, previously mixed with a little wort, at a temperature of about 85° Fahr, and kept until the whole has begun to ferment (technically termed "*lobb*"), is now added, and after agitation the vessel is left until the fermentation is well established. By this time the temperature has risen from 9° to 15°.

The quantity of yeast employed, and the temperature of the wort when it is added, differ in different breweries and for different kinds of beer. It seldom exceeds 2 lbs. per barrel unless the weather is unusually cold, or the yeast old or stale, when a larger proportion is required. The Scotch brewers generally take only 1 gallon of yeast to fully 4 hhds. of wort.

In England the temperature at which the yeast is added varies from 55° to 65° Fahr. In Scotland, the common temperature is 51° to 52°. In cold weather the heat may be 5° or 6° higher than in mild and warm weather, and a little more yeast may also be advantageously employed. In cold weather ale is commonly tunned at 60°, porter at 64°, and weaker beers at 65° or 70° Fahr. In warm weather strong beer should be 4° or 5°, and other beers 7° or 8° cooler than the "heats" just mentioned. On the small scale, 1 to $1\frac{1}{4}$ pint of yeast may be used to every barrel of

strong-beer wort, and $\frac{3}{4}$ pint to every barrel of mild-beer wort.

The commencement of the fermentation is indicated by a line of small bubbles forming round the sides of the tun and in a short time extending over the whole surface. A "crusty head" soon forms, and then a "fine rocky head," followed by a "light frothy" one. At length the head assumes a yeasty appearance, the colour becomes yellowish brown, and a vinous odour is developed. As soon as this last head begins to fall, the tun is skimmed every two or three hours, until no more yeast is formed. The object of this is, not only to check the violence of the fermentation, but also to remove a peculiar bitterness with which the first portion of the yeast is impregnated. The beer is then put into casks, or "cleansed," as it is called. A minute attention to every stage of this process is necessary to secure a fine flavour and a brilliant beverage.

It may be regarded, as a rule, that the lower the temperature, and the slower, more regular, and less interrupted the process of fermentation, the better will be the quality of the brewing, and the less likely to change by age. A little more yeast is required in winter than in summer. When the fermentation becomes slack in the "gyle-tun," a little more "lobb" is generally added, and the whole is well "roused up." On the contrary, if the temperature rises considerably, or the fermentation becomes too brisk, the wort is cooled a little and skimmed, or at once cleansed.

Cleansing.—This process consists in removing the yeast from the beer as the fermentation is being brought to a conclusion, and is usually commenced when the fermenting wort has been attenuated down to about 10 lbs. per barrel. It is conducted in various ways in different parts of the country. In London breweries, cleansing is frequently carried out by running the partially fermented wort into

smaller vats, holding from 5 to 10 barrels each, called pontoons, which are placed in a row with a channel by the side of them into which the yeast flows as it works off. At Burton, a somewhat similar system is adopted, but the fermenting casks, there called "union casks," are much smaller, holding only from 2 to 3 barrels; these unions communicate with each other through a pipe, and they are all connected with a cistern which contains some of the fermenting wort; at the top of each cask is a curved pipe, rising to a height of 2 or 3 feet, which from its shape is called a "swan's neck." The yeast is forced upwards through this "swan's neck," and escapes into a channel placed for its reception, whilst each union is continually kept full by the constant supply of wort arriving from the cistern before mentioned. In some of the large Burton breweries, the fermenting-rooms are a marvellous sight, containing as they do more than a thousand of these union casks. In Scotland, a system similar to the London one is adopted, but the pitching temperature is lower, and the activity of the fermentation is sustained by repeatedly beating in the yeast, or "rousing" as it is technically called. In Yorkshire, a peculiar method of fermentation, called the "stone square system," is still adopted. The fermenting tank is a large square, constructed of stone, inside is another smaller square, divided by a horizontal central partition into an upper and lower chamber, communicating by a small rectangular opening in the centre of the partition. The space between the two squares, can be filled with water of any temperature, so that the heats of the fermenting wort can be controlled; the fermenting wort is run into the lower internal chamber, and the yeast as it forms rises through the aperture referred to into the upper chamber.

Some brewers add a little wheat flour or bean flour (about $\frac{1}{4}$ lb. per barrel) to the beer in the gyle-tun, shortly before

cleansing, to quicken the discharge of yeast; but it is not clearly ascertained whether such a plan is advantageous, or the contrary.

Theory of Fermentation.—According to Liebig, the nitrogenous matter in a fermenting liquid, whilst itself undergoing decomposition, disturbs the equilibrium of the atoms forming the molecule of sugar, and the motion thus set up causes a rearrangement of the elementary atoms of the sugar which results in the production of alcohol and carbonic acid. This theory, which appeared to have much to support it, has, however, had to give way before the physiological theory as propounded by Pasteur, according to which, fermentation is due to the living organisms of the yeast-plant (*Saccharomyces cerevisiæ*). These minute cells absorb the saccharine fluid, and, in fact, digest a portion of it, assimilating some and excreting a large proportion, in the form of carbonic acid and alcohol. The chemical change which takes place during the fermentation of sugar may be expressed by the following equation—

$$\underset{\text{Glucose.}}{C_{12}H_{24}O_{12}} = \underset{\text{Alcohol.}}{4\,C_2H6O} + \underset{\text{Carbonic Acid.}}{4\,CO_2.}$$

According to this, 100 parts of glucose would produce about 51 parts of alcohol and 49 parts of carbonic acid; but, as a matter of fact, Pasteur found that during alcoholic fermentation, small quantities of succinic acid and glycerine were always formed, and the equation is therefore not quite so simple as the one we have just given. The yeast cells, which bring about this remarkable chemical change, are very minute; and therefore necessitate the use of a microscope of very high power for their detection The cells are propagated by budding, the cellulose, of which the walls are constructed, being formed out of the sugar and dextrine of the wort, and the interior being filled with a substance of

nitrogenous character known as protoplasm. As the new cells are produced, vacuoles appear in the mother cell, the protoplasm shrinks up, and the cell walls get thicker. It is of course important to have a large crop of young and vigorous cells; and a simple method of detecting any old and enfeebled cells is that devised by Lintner—viz., to add to the water of dilution a little aniline blue, which, though resisted by the young strong cells, penetrates the old and effete ones, thus making them distinctly manifest. Yeast cells are frequently accompanied by other organisms, and attacked by parasites, and these foreign organisms, which bring about various deleterious changes in a fermenting wort, have been called "disease ferments" by Pasteur. Impure yeast contains the lactic, acetic, and butyric ferments, producing the different acids after which they are named; also bacteria and vibrios, which give rise to putrefactive changes; and occasionally there are peculiar ferments met with such as *saccharomyces Pastorianus*, *saccharomyces exiguus*, &c. Pasteur's researches on alcoholic fermentation have led to the enunciation of the following well-established laws:—1. "Every unhealthy change in the quality of beer coincides with a development of microscopic germs, which are alien to the pure ferment of beer." 2. "The absence of change in wort and beer coincides with the absence of foreign organisms." Pasteur further found that a temperature of 131° Fahr., was sufficient to destroy these disease germs, but not sufficient to completely kill the pure yeast cells; he therefore proposed that fermented beverages, such as beer and wine, should be heated in closed vesels to this temperature, with the object of preventing subsequent objectionable changes, and this process, technically called "Pasteurizing" has since been practically carried out, especially in some Continental breweries. Pure yeast is of two kinds, termed

respectively "high" and "low" yeast; the former is the yeast usually met with in English breweries, and is the product of a fermentation conducted at a comparatively high temperature. As its name implies, this kind of yeast is thrown up to the surface of the fermenting wort; "low" yeast, on the contrary, is thrown down during fermentation, and is met with in Continental breweries, where lager beer, and other beers, fermented at very low temperatures, are produced.

Pasteur has suggested a process for the manufacture of an "unalterable beer." He states that the liability of beer to turn sour, ropy, &c., is due to the presence of special ferments derived from the air, and from the materials used. By boiling the infusion of malt and hops, cooling out of contact with air, and fermenting with pure yeast in vessels to which only carbonic acid or pure air is admitted, a beer is produced of superior quality, which may be preserved without trouble for any time. Even a partial adoption of these precautions is attended with valuable results. In preparing pure yeast to start with, the author makes use of the fact that oxygen favours the growth of true yeast, but hinders the propagation of the other ferments. Pure yeast being obtained, the beer is afterwards fermented in an atmosphere nearly destitute of oxygen, as its quality is thereby improved. Pure yeast when kept in pure air undergoes no change, even at summer temperature. The *mycoderma vini* does not, as the author once thought, become changed into beer-yeast on submersion in a nutritive fluid; under these circumstances it acts as an alcoholic ferment, but does not propagate itself.

Storing.—As soon as the fermentation is concluded, which generally takes from 6 to 8 days, or longer, the clear liquor is pumped into the store-casks or vats, which are then closely bunged, and deposited in a cool cellar, if not already there, to mature. The preference, which at present exists

in most parts of the United Kingdom, is for mild, freshly-brewed malt liquors; the good old or mature vatted beer being now seldom met with. This, of course, is a source of increased profit to the brewer, as it enables him to turn over his capital more rapidly, and saves the risk and expense attendant on long storage.

Ripening.—After a period varying from one to twelve months or longer, according to the nature of the brewing and the condition of the cellar, the liquor will have become fine, and sufficiently mature for use. During this period the casks, &c., should be occasionally examined to see that there is no leakage, and to open the vent-holes, should any oozings appear at the joints. As equable a temperature as possible should be maintained in the cellar, by ventilation, on the one hand, and the employment of artificial heat on the other, as circumstances and seasonal changes may render necessary.

Fining or Clarifying.—Beer which has been badly brewed or badly stored, or which from other causes may be thick or muddy, requires clarifying by artificial means. For a barrel, about 1 to $1\frac{1}{2}$ pint of brewer's finings (isinglass or fish-gelatin dissolved in sour beer) is put into a bucket, and some of the beer being gradually added, the whole is violently agitated with a whisk until a frothy head is formed. The mixture is then thrown into the cask of beer, and well "rummaged up," after which the bung is replaced, and the liquor allowed to repose for a week or ten days.

Sometimes the above method is found to fail with weak and bad-conditioned beer. When such is the case, a handful of hops, previously boiled for five minutes in a little of the beer, and then added to the barrel, and the whole allowed to stand for a few days, before proceeding to clarify it, will generally have a similar effect, and cause the "finings" to act with certainty. It is the absence of the

proper quantity of astringent matter in beer that usually renders them ineffective.

VARIETIES OF BEER.

The numerous varieties of malt liquor met with in commerce may be resolved into two great classes—ALE and PORTER. ALE of all kinds is brewed chiefly from pale malt, and is generally of a light amber colour. PALE ALE is manufactured from the finest and lightest dried malt, and the choicest hops, the latter in excess. MILD ALE differs from pale ale in being sweeter, stronger, and almost free from the flavour of the hop. BITTER ALE or BITTER BEER has, as a rule, less body than pale ale, and is more highly hopped. TABLE BEER is a weak liquor commonly containing three or four times the proportion of water usually present in ordinary beer or ale.

The stronger varieties of ale usually contain from 6 to 8 per cent. of "absolute alcohol;" ordinary strong ale, 4½ to 6 per cent.; mild ale, 3 to 4 per cent.; and table ale 1 to 1½ per cent. (each by volume); together with some undecomposed saccharine, gummy, and extractive matter, the bitter and narcotic principles of the hop, some acetic acid formed by the oxidation of the alcohol, and very small and variable quantities of mineral and saline matters.

Beers are classed by the brewers into—

Small beers—made from worts not exceeding the sp. gr. 1025, or 9 lbs. per barrel.

Middlings—made from worts of the sp. gr. 1030 to 1050, and averaging about 14 lbs. per barrel.

Strong beers—made from worts of the sp. gr. 1040 to 1080, extending from about 35 lbs. per barrel upwards

The densities of the worts employed for different kinds of beer vary considerably, as will be seen by the following table :—

TABLE *of the Densities of Beers.*

Description.	Pounds per barrel.			Specific Gravity.
Burton Ale, Class 1	40 to 43	...	...	1·111 to 1·120
,, ,, 2	35 ,, 40	...	...	1·097 ,, 1·111
,, ,, 3	28 ,, 33	...	...	1·077 ,, 1·092
Ordinary Ale	25 ,, 27	...	...	1·070 ,, 1·075
Common ,, ...	21	...	...	1·058
Scotch Ale, Class 1	40 to 44	...	...	1·111 to 1·122
,, ,, 2	33 ,, 40	...	...	1·092 ,, 1·111
Porter (ordinary)	18	...	...	1·050
,, (good)	18 to 21	...	...	1·050 to 1·058
,, (double)	20 ,, 22	...	...	1·055 ,, 1·060
Brown Stout	23	...	...	1·064
,, (best)	26	...	...	1·072
Table Beer	12 to 14	...	...	1·033 to 1·039
Small ,, (common) . . .	6	...	...	1·017

Porter.—This well-known beverage, originated with a brewer named Harwood, in 1722. Previously to this date, "ale," "beer," and "twopenny," constituted the stock-in-trade of the London publican, and were drunk, either singly or together, under the names of "half-and-half" or "three threads," for which the vendor was compelled to have recourse to two or three different casks, as the case might demand. The inconvenience and trouble thus incurred led Mr. Harwood to endeavour to produce a beer which should possess the flavour of the mixed liquors. In this he succeeded so well that his new beverage rapidly superseded the mixtures then in use, and obtained a general preference among the lower classes of the people. At first this liquor was called "entire" or "entire butt," on account of it being drawn from one cask only; but it afterwards acquired, at

first in derision, the now familiar name of "porter," in consequence of its general consumption among porters and labourers. The word "entire" is still, however, frequently met with on the signboards of taverns about the metropolis.

The characteristics of pure and wholesome porter are its transparency, lively dark-brown colour, and its peculiar bitter and slightly burnt taste. Originally, these qualities were derived from the "high-dried malt," with which alone it was brewed. It is now generally, if not entirely, made from "pale" or "amber malt," mixed with a sufficient quantity of "patent" or "roasted malt" to impart the necessary flavour and colour. Formerly, this liquor was "vatted" and "stored" for some time before being sent out to the retailer, but the change in the taste of the public during the last quarter of a century in favour of the mild or new porter has rendered this unnecessary. The best "draught porter," at the time of its consumption, is now only a few weeks old. In this state only would it be tolerated by the modern beer-drinker. The old and acid beverage that was formerly sold under the name of porter would be rejected at the present day as "hard" and unpleasant, even by the most thirsty votaries of malt liquor. PORTER differs from ale chiefly in its being artificially coloured by the use of roasted malt, which also imparts to it a peculiar bitter flavour. In point of strength it stands about midway between light and strong ales, although frequently brewed of a strength very slightly above that of table beer. STOUT, BROWN STOUT, &c., are simply richer or stronger descriptions of porter, and may be said to have nearly the same relation to the higher qualities of mild ale that porter holds with regard to pale ale or bitter beer. In London, PORTER is called BEER; and, indeed, in all parts of the kingdom, the prevailing beverage of this kind consumed by the masses, of whatever class, commonly goes by the name of beer.

Pale Ales.—In brewing the finer kinds of ale, pale malt and the best East Kent hops of the current season's growth, are always employed; and when it is desired to produce a liquor possessing little colour, very great attention is paid to their selection. With the same object, the boiling is conducted with more than the usual precautions, and the fermentation is carried on at a somewhat lower temperature than that commonly allowed for other varieties of beer. For ordinary ale, intended for immediate use, the malt may be all pale; but, if the liquor be brewed for keeping, and in warm weather, when a slight colour is not objectionable, one-fifth, or even one-fourth of "amber malt" may be advantageously employed. From 4½ lbs. to 6 lbs. of hops is the quantity commonly used to the quarter of malt for "ordinary ales;" and 7 lbs. to 10 lbs. for "keeping ales." The proportions, however, must greatly depend on the intended quality and description of the brewing, and the period that will be allowed for its maturation.

East-India Ale or Pale Ale, for exportation, is brewed from worts of a sp. gr. of from 1·063 to 1·070. For the best varieties, 15 to 16 lbs. of the finest East Kent hops are used to every quarter of pure malt. The process now adopted by the great brewers of pale ale at Burton-on-Trent combines all the most admirable points of both the Bavarian and Scotch systems of brewing.

The preceding is a concise account of all the essential operations of the system of brewing at present practised in this country. On the large scale, extensive and costly apparatus and machinery are employed for the purpose. On the small scale, various modifications, of a minor character, of the several processes herein detailed, are frequently adopted according to the circumstances or ingenuity of the operator. The principles and practice of brewing beer are, however, essentially the same under all the conditions here

referred to. In Scotland, only one mash is made, and that at a temperature of about 180° Fahr., with one-third of the quantity of the water required for the brewing. The "mash-tun" is then covered up for about half an hour, when the wort is drawn off, and the operation of "sparging" begun. This operation is continued until the density of the mixed worts becomes adapted to produce the quality of the ale then under process of manufacture. The "gyle-tun" (fermenting-tun) is set at from 50° to 60° Fahr., the fermentation being continued slowly for fifteen to twenty days; and the ale is not "cleansed" before the degree of attenuation falls to about ½ lb. per day, and not more than one-fourth of the original gravity of the wort remains. Scotch ale is justly celebrated for its superior quality. Its usual original gravity is from 34 to 45 lbs. per barrel.

In Bavaria, a country remarkable for the excellence of its beer, the wort is made to ferment at a low temperature, until all the substances which favour acetification have been rendered insoluble, and have separated from the liquor. The fermentation is conducted in wide, open, shallow vessels, which afford free and unlimited access to atmospheric oxygen; and this in a situation where the temperature does not exceed 45° to 60° Fahr. A separation of the nitrogenous constituents thus takes place simultaneously on the surface, and within the whole body of the liquid. The clearing of the fluid is the sign by which it is known that these matters have separated. The fermentation usually occupies three or four weeks, and is conducted during the cooler portion of the year only, and in a situation removed as much as possible from the influence of atmospherical changes of temperature. The sedimentary yeast (*unterhefe*), and not the surface yeast (*oberhefe*), of the Bavarian fermenting backs is employed.

The beers of England and France, as well as most of those

of Germany, become gradually sour by contact with the air. This defect, as observed by Liebig, does not belong to the beers of Bavaria, which may be preserved, at pleasure, in half-full casks, as well as in full ones, without suffering any material alteration. This precious quality must be ascribed to the peculiar process employed for fermenting the wort, called by the German chemists "untergährung," or fermentation from below; and which "has solved one of the finest theoretical problems that had long taxed the ingenuity and patience of both the scientific and practical brewer.' (Liebig.)

The best times for brewing are the spring and autumn; as at those periods of the year the temperature of the air is such as to permit of the easy cooling of worts sufficiently low, without having recourse to artificial refrigeration, or to the use of machinery for the purpose. Stock ale cannot be conveniently brewed in summer.

COMPOSITION OF BEERS.

The following beer analyses are given by Professor Wanklyn:—

Bass's bottled bitter ale contains in 100 cubic centimètres:

5·3	grams of	alcohol.
5·52	,,	organic residue.
0·36	,,	ash.

A sample of draught ale, costing *2d.* per pint in London, contained in 100 cubic centimètres:

4·7	grams of	alcohol.
5·8	,,	organic residue.
0·32	,,	ash.

A sample of London porter in 100 cubic centimètres contained:

3·3 grams of alcohol.
3·45 ,, organic residue.
0·30 ,, ash.

A large number of analyses recently made show that in the various classes of malt liquor sold in London there is a variation in the amount of alcohol contents from 3·87 to 8·41 per cent. of absolute alcohol by weight, these two extremes corresponding to ·98 and 2·18 fluid ounces of absolute alcohol in the pint of beer. The amount of extract varies from 2·16 to 13·32 per cent. by weight, or from ·73 to 2·77 ounces per pint of beer, as will be seen from the accompanying table:—

Kind of Malt Liquor.	Specific Gravity.	Percentage of			Original Gravity of Wort.	Malt, per barrel.	Con. vols., per pint.		
		Alcohol.	Extract.	Acetic Acid.			Alcohol, fl. oz.	Extract ounces.	Acid, grains.
Burton Ale (Allsopp's)	1040·38	8·25	13 32	0·32	1121·63	4·50	2·16	2 77	29·12
Bass's Barley Wine	1032·31	8·41	11 75	0·23	1114·78	4·25	2·18	2 42	20·77
Edinburgh Ale . . .	1006·63	4·41	3 58	0·19	1048·38	1·77	1·12	0·72	16·73
Guinness's Stout . .	1015 51	6·81	6 17	0·24	1078·06	2·88	1·74	1·25	21·32
Truman, Hanbury, & Co.'s Porter .	1013·16	4·02	5·12	0 24	1051·33	1·90	1·03	1·01	21·27
Whitbread's Porter .	1014·04	4·28	5·15	0 18	1054·11	2·00	1·09	1·03	15·97
Hoare's Porter . .	1012·99	4·18	5·04	0·18	1052·42	1·94	1·06	1·03	15·95
Perry's Ale	1006·48	3·87	3·65	0·14	1045 82	1·69	0·98	0·73	7·97

The most recent analyses of beers are those published by Professor GRAHAM in his interesting paper on Lager Beer, read before the Society of Chemical Industry, from which we quote the following:—

Analysis of British Beers. (Weight on Volume).

	ENGLISH VARIOUS.											SCOTCH VARIOUS.				Dublin Stout.	
	Burton.			Mild X.	XX.	XXX.	X.	AK Bitter.	AK Bitter.	Somersetshire Old Vat Ales.		Mild.	Export Bitter.	Bitter.	Bitter.	XX.	XXX.
	Mild.	Pale.	Bitter.							A. 2 years.	B. 3 years.						
Maltose	2·13	1·75	1·620	1·870	1·990	2·880	2·14	0·84	0·810	1·54	1·363	1·50	1·621	0·87	0·87	3·450	5·350
Dextrine	3·64	2·48	2·601	1·881	1·728	2·045	1·37	1·48	0·754	2·48	1·963	1·86	2·500	1·45	1·38	3·070	2·090
Albuminoids (Wanklynized)	0·26	0·21	0·156	0·201	0·202	0·300	0·23	0·16	0·207	0·42	0·705	0·35	0·300	0·30	0·32	0·260	0·430
Lactic and Succinic Acids	0·18	0·14	0·171	0·144	0·151	0·098	0·09	0·10	0·144	0·64	0·630	0·14	0·091	0·10	0·20	0·172	0·252
Colouring matters, hop extract, ash, &c. (by difference)	0·53	0·55	0·876	1·301	1·368	1·477	1·17	0·39	0·849	0·94	0·835	0·23	0·700	0·48	0·78	1·760	1·400
Total solids	6·74	5·13	5·424	5·397	5·439	6·800	5·00	2·97	2·764	6·02	5·496	4·08	5·212	3·20	3·55	8·712	9·522
Acetic Acid	0·01	0·02	0·015	0·036	0·031	0·024	0·01	0·03	0·060	0·07	0·225	0·03	0·160	0·02	0·03	0·012	0·036
Alcohol by weight	6·78	5·37	5·440	4·600	5·130	6·500	3·29	4·34	4·690	6·50	8·570	4·62	5·000	5·50	5·87	5·500	6·780
Water by difference	86·47	89·48	89·121	89·967	89·400	86·676	91·70	92·66	92·486	87·41	85·709	91·27	89·628	91·28	90·55	85·776	83·662
	100·00	100·00	100·000	100·000	100·000	100·000	100·00	100·00	100·000	100·00	100·000	100·00	100·000	100·0	100·00	100·000	100·000
Alcohol by volume	8·45	6·71	6·78	5·76	6·41	8·10	4·12	5·44	5·86	8·10	10·60	5·78	6·24	6·86	7·32	6·86	8·45
"Original gravity"	1080°	1062°	1064°	1055·5	1060·7	1073·7	1044°	1045°	1044·6	1071°	1085°	1053°	1057°	1057°	1059°	1074°	1089°
Ratio of Maltose to Dextrine	$\frac{1}{1·7}$	$\frac{1}{1·4}$	$\frac{1}{1·6}$	$\frac{1}{1}$	$\frac{1}{0·87}$	$\frac{1}{0·7}$	$\frac{1}{0·6}$	$\frac{1}{1·07}$	$\frac{1}{1}$	$\frac{1}{1·6}$	$\frac{1}{1·38}$	$\frac{1}{1·2}$	$\frac{1}{1·5}$	$\frac{1}{1·7}$	$\frac{1}{1·6}$	$\frac{1}{0·88}$	$\frac{1}{0·39}$

Analyses of German Beers. (Weight on Volume.)

	Sold in London.			Sold in Germany.		
	Vienna.	Pilsen.	Tivoli.	Vienna.	Pilsen.	Munich
Gravity of Wort	1052·4	1045·5	1062·0	1058·6	1040·3	1064·0
Gravity of Beer	1015·0	1005·0	1014·0	1016·5	1011·8	1021·0
Solids in Beer	5·340	3·102	5·580	5·991	4·21	7·080
Nitrogen (by Soda Lime)	0·084	0·082	0·060	0·134	0·090	0·103
Albuminoids (Wanklynized)	0·240	0·195	0·170	0·365	0·200	0·400
Alcohol	4·250	4·440	5·310	4·690	3·290	4·750
Maltose	1·054	0·534	1·750	1·643	0·690	1·570
Dextrine	2·847	1·440	2·150	2·736	2·650	3·150
Lactic and Succinic Acids	0·090	0·080	0·120	0·126	0·090	0·140
Acetic Acid	0·036	0·018	0·020	0·024	0·020	0·010
Colouring Matters, Hop Extract, Ash, &c.	1·109	0·953	1·390	1·121	0·590	1·820
Water by difference	90·374	92·340	89·090	89·295	92·470	88·160
	100·000	100·000	100·000	100·000	100·000	100·000
Alcohol by volume	5·32	5·60	6·63	5·86	4·12	5·94
Ratio of Maltose to Dextrine	$\frac{1}{2·7}$	$\frac{1}{2·7}$	$\frac{1}{1·23}$	$\frac{1}{1·66}$	$\frac{1}{3·8}$	$\frac{1}{2}$

The leading characteristics of good beer are transparency, a fine colour, an agreeable semi-vinous flavour, and the property of remaining for several hours exposed in a glass or cup without becoming "flat" or insipid. If the materials used were good, if the brewing was skilfully conducted, if the liquor has been carefully stowed in perfectly sweet casks or vessels, in a suitable cellar, for a sufficient time, and has not been tampered with, this will almost always be the case. Hence colour, transparency, and flavour, and the power of resisting exposure, are tests of the purity and quality of beer, which should not be lightly treated. There are none more simple and effectual; and, together with a good "palate," and a close observance of its effects on the head and on the stomach, will readily distinguish pure and wholesome beer from "doctored" and inferior liquor. If, therefore, we find a sample of beer possessing the above qualities and in good condition, and on testing it for its alcohol and saccharine matter, find these substances in such quantities as fairly to represent the amount of malt which

should have been used in the brewing of such a liquor, we may, in the absence of proof to the contrary, infer it to be pure; because the object for which adulteration is practised —the saving of malt and hops—did not exist in this case. To demonstrate the purity of beer requires an elaborate and troublesome analysis, which can only be performed by those accustomed to chemical operations. Good and pure beer should contain nothing but what exists in the legitimate materials from which it is brewed, or which is produced from them in the process of brewing.

CHAPTER III.

CIDER.

CIDER is the fermented juice of the apple, and is a very ancient beverage. Pliny calls cider and perry the "wine of apples and pears."

The attention of the cider farmer should be first directed to the culture of the apple tree. The situation most appropriate for an orchard is one on rising ground, rather dry than moist, and unexposed to sea air or high winds. The soil should be strong, but not too heavy, and should be rich in the alkaline and earthy bases, especially the phosphates. The apples should be gathered in dry weather. The selection of the proper varieties of the apple for grafting is also a point on which particular care should be taken. It is found that the juices of different kinds of apples vary in the quantity of saccharine matter which they contain, as well as in other particulars that influence the quality and flavour of the cider prepared from them. As a general rule, those varieties should be chosen that yield a juice rich in sugar, and contain no undue amount of acid, and which, after the period of active fermentation is past, furnish a liquor which clarifies spontaneously and keeps well. This quality of the juice may generally be determined from its specific gravity. The heaviest and clearest is the best, other points being equal. The specific gravity of the juice of the different varieties of apple varies from 1·060 to 1·100.

Cider apples are classed under three heads:—bitter, sweet,

and sour. The first are the best; their juice has the greatest specific gravity, is richest in sugar, ferments most freely, clarifies spontaneously and quickly and best after fermentation. The bitter variety also contain a minute quantity of extractive matter which is not present in other apples. The juice of sweet apples ferments tumultuously, clears with difficulty, and the resulting cider does not keep so well as that produced from the bitter apples. The juice of sour apples contains less sugar and more acid than either the bitter or the sweet kind, and consequently it not only produces the weakest, but the worst, cider; it, however, "fines" well, although it "stores" badly. Sour and "rough-tasted" apples are usually preferred by farmers for making cider. This preference, which is very decided in the West of England, may be readily accounted for. The sour and rough-tasting apples contain less sugar and more malic acid than some of the other varieties, and the presence of this acid impedes the conversion of the alcohol of the cider into vinegar; a change which the rude mode of operating upon them renders otherwise inevitable. But cider made from such fruit is never equal in quality to that prepared at a low temperature from apples abounding in sugar, if as much skill and care be exercised in its manufacture as is bestowed upon the process of converting malt-worts into beer.

The process of making cider varies in different places, but in every case essentially consists of the collection of the fruit, the expression and fermentation of the juice, and the storing and management of the fermented liquor.

The collection of the fruit should not be commenced before it has become sufficiently mature, and should be performed with greater care than is commonly bestowed upon it. The apples, after being gathered, are usually left for fourteen or fifteen days in a barn or loft to mellow, during which time a considerable portion of the mucilage is decomposed, whilst

alcohol and carbonic acid are developed. "The mellowing may in general be known to be completed when the texture has so far given way that the thumb may without difficulty be thrust through one of the apples of an average quantity selected for the trial." If the mellowing is allowed to go too far, loss arises, notwithstanding the common prejudice in its favour. The spoiled apples are then separated from the sound ones, as they not only impart a bad flavour to the cider, but impede its spontaneous clarification.

The expression of the juice is the next step in the process of cider-making. The apples are either crushed or ground in mills consisting of two fluted cylinders of hard wood or cast-iron, working against each other, or in a mill fitted with stones revolving on their edges, in a circular stone cistern, the stones being turned by horses. When the former method is followed, the fruit has to be submitted to three different crushings. The common practice is next to sprinkle the pulp with one-sixth to one-fourth its weight of spring or river wate. and then to allow it to remain in tubs or wooden cisterns for twelve or twenty-four hours, during which time incipient fermentation commences, and the breaking up of the cells of the membrane takes place, by which the subsequent separation of the juice is facilitated. This plan, though general among cider manufacturers, is prejudicial to the quality of the future liquor; as not only is a portion of the newly formed alcohol lost, but the skins and pips often impart to it a disagreeable flavour. By employing more efficient crushing machinery this system of vatting is rendered quite unnecessary. A machine furnished with a revolving circular rasp, similar to that used in making potato starch, is admirably adapted to this purpose.

The pulp of the crushed or ground apples is now placed layer upon layer, on a kind of wicker frame, or in hair-cloth

* Webster and Parkes.

or coarse canvas bags, sometimes between layers of straw, and after being allowed to drain into suitable tubs or receivers, is subjected to powerful pressure, gradually applied, in the cider press. The liquor which runs off first is the best, and is usually kept separately; whilst that which follows, especially the portion obtained by much pressure, tastes of the pips and skins.

The expressed juice or "must," obtained as above, is next put into clean casks with large bung-holes, and freely exposed to the air and the shade, the casks being placed on "stillions," with flat tubs under them to catch the waste. The casks must be kept quite full, in order that the yeast, as it forms, may froth over and be carried off from the surface of the liquor. After two or three days for weak, and eight or ten days for strong, cider, or as soon as the sediment has subsided, the liquor is "racked off" into clean casks, which, according to the common practice, have been previously sulphured with a cooper's match. The casks containing the "racked cider," are then stored in a cellar, shaded barn, or other cool place, where a low and regular temperature can be ensured, and their contents are left to mature or ripen. By the following spring the cider is commonly fit for use, and may be "re-racked" for sale.

The marc, or pressed pulp, is generally again sprinkled with one-third or one-half its weight of water, and re-pressed. The resulting liquor, when fermented, forms a weak kind of cider known as "cider-moil," or "water-moil," this being reserved for domestic use. The refuse-pulp, called "apple-marc," "pomace" "pomage," "apple-cheese," is used as food for pigs and store cattle, and is readily eaten by them.

The storing and management of cider are matters of great importance to the cider farmer, the factor, the wholesale dealer, and the bottler, for the guidance of whom directions on these points will be found under Brewing, page 56, since the principles upon which these operations are conducted

apply equally to the treatment of cider and beer. Preparatory to its being bottled, the cider should be examined, to see whether it is clear and sparkling. If not, it should be clarified in a similar way to beer, and left for a fortnight. The night before it is intended to put it into bottles, the bung should be taken out of the cask, and left so until the next day, and the bottles when filled should not be corked down until the day after; otherwise many of them will burst by being kept. The best corks should be used. Champagne bottles are those generally chosen for bottling. Brébisson, however, a French authority, gives the preference to stoneware bottles. It is usual to wire down the corks, and to cover them with tinfoil, after the manner of champagne. A few bottles at a time may be kept in a warm place to ripen. When the cider is wanted for immediate use, or for consumption during the cooler portion of the year, a small piece of lump sugar may be put into each bottle before corking it; or the bottles may be corked within two or three hours after being filled. In summer, and for long keeping, this practice is, however, inadmissible. The bottled stock should be stored in a cool cellar, when the quality will be greatly improved by age. Cider for bottling should be of good quality, sound and piquant, and at least a twelve-month old. When out of condition it is unfit for bottling.

Cider, when of good quality, and in good condition, is regarded as a very wholesome beverage. Cider consumers living in the cider districts, are said to enjoy almost an immunity from cholera and other epidemic diseases. At the same time, dry colic or belly-ache (*colica pictonum*) is far from uncommon in the cider drinking districts; but as these attacks are wholly confined to those who drink inferior cider, made from harsh, unripe fruit, it seems reasonable to infer that, in most cases, they may be referred to the acid of the common cider having acted on the lead, pewter, or

copper of the articles or utensils with which it has come into contact, and of which it has dissolved a very minute portion. The best cider contains from 8 per cent. to 10 per cent. of absolute alcohol; ordinary cider from 4 per cent. to 6 per cent

Much of the excellence of cider depends upon the temperature at which the fermentation is conducted; a point utterly overlooked by the manufacturers of this beverage. The apple-juice, as soon as it is expressed from the fruit, instead of being placed in a cool situation, where the temperature should not exceed 50° or 52° Fahr., is frequently exposed to the full heat of autumn. Thus a considerable quantity of the alcohol formed by the decomposition of the sugar is converted into vinegar by the absorption of atmospheric oxygen, and thus the liquor acquires that peculiar and unwholesome acidity known in the cider districts by the name of "roughness." When, on the contrary, the fermentation is conducted at a low temperature, nearly the whole of the sugar is converted into alcohol, and this remains in the cider instead of undergoing the process of acetification. The acetous fermentation, by which alcohol is converted into vinegar, proceeds most rapidly at a temperature of about 90° Fahr., and at lower temperatures the action becomes gradually slower, until at 46° to 50° Fahr. no such change takes place.* It is therefore evident that if the saccharine juice of apples, or any other fruit, be made to undergo the vinous fermentation at a sufficiently low temperature, less of the spirit resulting from the transformation of the sugar will be converted into acetic acid, and, consequently, not only will the liquor be richer in alcohol, but the latter, from its antifermentative property, will prevent the cider from undergoing future change. This is the principal cause,

* Liebig.

other circumstances being alike, of the difference in the quality of the cider made by persons residing in the same district. The one has probably a cooler barn and cellar than the other in which to store his liquor, and is most likely more careful to keep the pulp and juice cool during the early part of the process. In Devonshire the pressing and fermentation are conducted in situations where the temperature varies little from that of the external air, and fluctuates with all its changes; with the result that Devonshire cider, of the best class, will rarely keep more than four or five years, and seldom improves after the second or third year; whilst the cider of Herefordshire and Worcestershire, where more care is bestowed upon these points, will keep for twenty or thirty years.

When the pressing of the apples is deferred until late in the season, it sometimes happens that the fermentation is sluggish. Though the juice has been set on the old system, in November or December, the working hardly commences until March. At this time the cider is sweet; it now rapidly becomes pungent and vinous, and is soon ready to be racked for use. If the fermentation still continues, it is again racked into a clean cask* that has been sulphured; or two or three cans of the cider are put into a cask, and a brimstone-match burned in it. The cask is then agitated, after which it is nearly filled with the cider. By this process the fermentation is checked, and the cider in a short time becomes fine. Great care must be taken that the sulphuring be not over-done, as it is liable to impart a slightly unpleasant flavour to the liquid. If, after the first operation, the fermentation is not checked, the process of

* New casks, in spite of being well seasoned, sometimes impart an unpleasant taste to the cider. This may sometimes be overcome by pouring a decoction of boiling pommage into them.

"racking" must be repeated, until the liquid becomes clear, and be continued, if necessary, from time to time, till the cider is in a quiet state and fit for drinking.

For the purpose of checking fermentation, a common practice in Devonshire was to add a stuff called "stum," sold by the wine-coopers, or an article called "anti-ferment," obtained from the druggists. The method of sulphuration, described above, is, however, much to be preferred.

To improve the flavour of weak cider, or to render ordinary cider more vinous, various plans are followed by the cellarmen and bottlers; one of which consists in adding to each hogshead, 1½ galls. of good brandy or rum, with 2 oz. of powdered catechu suspended in water, 10 lbs. of good moist sugar or honey, ½ oz. each of bitter almonds and cloves, and 4 oz. of mustard seed; all in powder. These must be well "rummaged" into the liquid, and the whole occasionally stirred up for a fortnight, after which it must be allowed to repose for three or four months, at the end of which time it will usually be found to have become perfectly bright. Should it not have done so, the liquid must be fined with a pint of isinglass finings, or a dozen eggs, and allowed to rest for a fortnight. If the cider is preferred pale, the catechu must be omitted, and instead of isinglass, a quart of skimmed milk is to be used as finings. When desired of a pinkish tint, 1 oz. of cochineal in powder may be added instead of the catechu.

About 13 cwt. of November apples commonly yield one hogshead of cider. In Devonshire about 6 sacks or 24 bushels are the common quantity for the hogshead of 63 gallons.

The best cider is that of Normandy, Herefordshire, and New Jersey (U.S.), then that of Devonshire and Somersetshire.

Cider for domestic purposes, and in small quantities, may

be made according to the following process,* from the superabundant apples supplied by a large garden :—The fruit should be picked free from stalks, and laid in heaps for three weeks to mellow. A thick and strong tub, 18 inches in diameter, and iron-hooped, may be used as a crushing trough, and the apples should be made into a pulp with a heavy bruiser of hard wood, not unlike that of a street-pavior. A strong clothes'-prop may be employed for pressing the apples, the lower pressing-board being placed in a tin tray to collect the juice, which must run down by a pipe connected with the tray into a vessel placed to receive it. The apples to be pressed must be put into hair, cloth, or canvas bags. Only a few apples must be pounded at a time, and the pressing must be gradual, the application of too much force suddenly applied, being avoided. The fermentation may be carried on in a cask, and a hole should be bored in the head of the cask, which may be stopped when necessary by a bottle cork, through which the juice to be fermented may be poured, a cock being placed near the bottom of the cask, by which the fermented liquid may be drawn off. The fermentation should be promoted by the use of new yeast, mixed with a little honey and flour, and warmed. This mixture being put into a muslin bag, and inserted through the hole of the cask, is suspended by a string, but is not suffered to reach the bottom of the cask. In warm weather the fermentation should be carried on in the shade, at a temperature of about 60° Fahr. In cold weather the cask may be placed near the fire. September is the best month for conducting the operation. The fermentation must not be carried far, but only until the excessive sweetness of the apple has disappeared, and the liquid has a vinous taste. Five or six days will be generally

* Donovan.

found sufficient. When the fermentation is over, or nearly so, it is drawn off into smaller and perfectly clean casks (being strained in the process), which, when full, must be bunged, and kept for draught. After two or three weeks, the liquid may be bottled, when it will soon be matured. Cider made in cold weather takes a longer time to clear, and sometimes requires to be fined. Ten gallons of juice may be obtained in a day, if one man be employed to pound the fruit, and another to press it and to assist the first man. The juice should not be allowed to remain long in the tin tray, and the pounding and pressing should be as complete as possible.

Champagne Cider.—This name is given in the United States to a fine, pale variety of cider, much used for bottling, which has a great resemblance to inferior champagne. The best variety comes from New Jersey. The name is also applied in this country in a similar manner. The following is a form for a "made" cider of this class :—

Good pale vinous cider, 1 hhd.; proof spirit, 3 galls.; honey or sugar, 14 lbs.; mix well, and let them remain together in a moderately cool place for one month; then add orange-flower water, 3 pints; and in a few days fine it down with skimmed milk, ½ gall. A similar article, bottled in champagne bottles, silvered, and labelled, is said to be sometimes sold for champagne.

Made Cider.—An article under this name is made in Devonshire, chiefly for the supply of the London market, it having been found that the ordinary cider will not stand a voyage to the metropolis without some preparation. The finest quality of made cider is simply ordinary cider racked into clean and well-sulphured casks; but the mass of that which is sent to London is mixed with water, treacle, and alum. The cider sold in London under the name of Devon-

shire cider would be rejected even by the farmers' servants in that county.

Raisin Cider.—This is made in a similar way to raisin wine, but without employing sugar, and with only 2 lbs. of raisins to the gallon, or even more, of water. It is usually fit for bottling in 10 days, and in a week longer is ready for use. *See* WINES (BRITISH).

Spirit Cider.—*See* BRANDY CIDER.

Metheglin.—From honey, 1 cwt.; warm water, 24 galls.; stir well until dissolved; the next day add of yeast, 1 pint, and hops, 1 lb., previously boiled in water, 1 gall.; along with water q. s. to make the whole measure 1 barrel; mix well, and ferment the whole with the usual precautions adopted for other liquors. It contains on the average from 7 per cent. to 8 per cent. of alcohol.

Mum.—A beverage prepared from wheat malt, in a similar way to ordinary beer from barley malt. A little oat and bean meal is frequently added. It was formerly much drunk in England, but its use at the present day is chiefly confined to Germany, and to Brunswick more particularly.

Perry.—A fermented liquid prepared from pears in the same way as cider is from apples. The reduced pulp must not be allowed to remain long without being pressed. In the cask, perry does not bear changes of temperature so well as cider. It is therefore advisable, if at the end of the first succeeding summer it be in sound condition, to bottle it, when it will keep perfectly well. The red rough-tasted sorts of pears are principally used for making perry. They should be quite ripe, without, however, approaching to mellowness or decay. The best perry contains about 9 per cent. of absolute alcohol; ordinary perry from 5 to 7 per cent.

Perry is a very pleasant-tasted and wholesome liquid. When bottled champagne fashion, it is said to frequently pass for champagne without the fraud being suspected.

CHAPTER IV.

LIQUEURS AND CORDIALS.

Liqueurs and cordials are stimulating beverages, formed of weak spirit, aromatized and sweetened. The manufacture of liqueurs constitutes the trade of the compounder, rectifier, or liqueurist.

The materials employed in the preparation of liqueurs or cordials are rain or distilled water, white sugar, clean flavourless spirit, and flavouring ingredients. To these may be added the substances employed as finings, when artificial clarification is had recourse to.

The utensils and apparatus required in the business are those ordinarily found in the wine- and spirit-cellar; together with a copper still, furnished with a pewter head and a pewter worm or condenser, when the method by distillation is pursued. A barrel, hogshead, or rum puncheon, sawn in two, or simply unheaded, as the case may demand, forms an excellent vessel for the solution of the sugar; and two or three fluted funnels, with some good white flannel, will occasionally be found useful for filtering the aromatic essences used for flavouring. Great care is taken to ensure the whole of the utensils, &c., being perfectly clean, sweet, and well seasoned, in order that they may neither stain nor flavour the substances placed in contact with them.

In the preparation or compounding of liqueurs, one of the first objects which engages the operator's attention is the production of an alcoholic solution of the aromatic principles

which are to give them their peculiar aroma and flavour. This is done either by simple solution or maceration, as in the manufacture of tinctures and medicated spirits, or by maceration and subsequent distillation. The products, in this country, are called ESSENCES or SPIRITS, and by the French INFUSIONS, and are added to the solution of sugar or syrup, or to the dulcified spirit, in the proportions required. Grain or molasses spirit is the kind usually employed for this purpose in England. As before observed, it should be of the best quality; as, if this is not the case, the raw flavour of the spirit is perceptible in the liqueur. Rectified spirit of wine is generally very free from flavour, and when reduced to a proper strength with clear soft water, forms a spirit admirably adapted for the preparation of cordial liquids. Spirit weaker than about 45 o. p., which has been freed from its own essential oil by careful rectification, is known in trade under the title of "pure," "flavourless," "plain," or "silent spirit." In France, brandy made from wine is occasionally employed. Before macerating the ingredients, if they possess the solid form, they are coarsely pulverized, bruised, sliced, or ground, as the peculiar character of the substance may indicate. This is not done until shortly before submitting them to the action of the menstruum; as, after they are bruised they rapidly lose their aromatic properties by exposure to the air. When it is intended to keep them for any time in the divided state they should be preserved in well-corked bottles or jars. The practice of drying the ingredients before reducing them to powder, frequently adopted by ignorant and lazy workmen for the sake of lessening the labour, is, of course, even more destructive to their most valuable qualities than mere exposure to the air. The length of time the ingredients should be digested in the spirit should never be less than 5 or 6 days, but a longer period is necessary when distillation

is not employed. When maceration alone is had recourse to, the French liqueurists allow the digestion in the spirit to extend over 30 or 40 days. In the former case the time may be advantageously extended to 10 days or a fortnight, and frequent agitation should be had recourse to during the whole period in both instances. When essential oils are employed to impart the flavour, they are first dissolved in a little of the strongest rectified spirit of wine; and when added to the spirit, they are mixed up with the whole mass as rapidly and as perfectly as possible. In managing the still, the fire is proportioned to the specific gravity of the oil or flavouring substance, and the receiver is changed before the faints come over; as these are unfitted to be mixed with the liqueur. In France, the heat is applied by a water-bath. In many cases, the addition of a few pounds of common salt to the liquid in the still facilitates the process and improves the product. Ingredients which are not volatile, are, of course, always added after distillation. The stronger spirit is reduced to the desired strength by means of either clear soft water, or the clarified syrup used for sweetening. The sugar employed should be of the finest quality,* and is preferably made into syrup before adding it to the aromatized spirit, which must, previous to admixture, be rendered perfectly fine or transparent, by filtration or clarification if necessary. Some spirits or infusions, as those of aniseed, caraway, &c., more particularly require this treatment, which is best performed by running them through a clean wine bag, made of rather fine cloth, having previously mixed them with a spoonful or two of magnesia; but in all cases clarification by simple repose is to be preferred. Under proper management, liqueurs or cordials prepared of

* A very excellent sugar in crystals is prepared by Finzel, of Bristol. It is largely employed in pharmacy because of its purity.

good materials will be found perfectly clear or bright as soon as made, or will become so after being allowed a few days for defecation; but in the hands of the inexperienced operator, and when the spirit employed is insufficient in strength or quantity, it often happens that they turn out foul or milky. When this is the case, the liquid may be fined down with the whites of 12 to 20 eggs per hogshead; or with a little alum, either alone, or followed by a little carbonate of sodium or potassium, dissolved in water.

An easy way of manufacturing cordial liquors and liqueurs, especially when it is inconvenient to keep a large stock on hand, is by simply aromatizing and colouring, as circumstances or business may demand, spirit 60 or 64 u. p., kept ready sweetened for the purpose. To do this to the best advantage, two descriptions of sweetened spirit should be provided, containing respectively 1 lb. and 3 lbs. of sugar to the gallon. From these, spirit of any intermediate sweetness may be made, which may be flavoured with any essential oil dissolved in alcohol, or any aromatized spirit or "infusion" (explained further on) prepared either by digestion or distillation. As a general rule, the concentrated essences, made by dissolving 1 oz. of the essential oil in 1 pint of the strongest rectified spirits of wine, will be found well adapted for this purpose. These essences, which should be kept in well-corked bottles, are employed by dropping them cautiously into the sweetened spirit until the desired flavour is produced. During this operation the liquid should be frequently and vigorously shaken or poured several times from one vessel to another, to produce complete admixture. If by any accident the essence is added in too large a quantity, the resulting milkiness or excess of flavour may be removed by the addition of a little more spirit, or by clarification. In this way the majority of

the liqueurs in common use may be produced extemporaneously, of nearly equal quality to those prepared by distillation. For those which are coloured, simple digestion of the ingredients is almost universally adopted. This method of extemporaneous preparation is called by the French liqueurists *illico.* The process by distillation should, however, be always employed to impart the flavour and aroma of volatile aromatics to the spirit, when expense, labour, and time are of less importance than the production of a superior article. All liqueurs are greatly improved if allowed to mature. Absinthe and walnut liqueurs are said by experts not to be ready for drinking for at least two years after they have been made. Of course, the products of the different stages of the distillation must be well mixed. The substance submitted to distillation ought to be one capable only of imparting to the distillate, the taste and flavour of its predominant and specific ingredient.

The French liqueurists are famed for the preparation of liqueurs of superior quality, cream-like smoothness, and delicate flavour. Their success chiefly arises from the employment of very pure spirit and sugar (the former in a larger proportion than that adopted by the English compounder), and in the judicious application of the flavouring ingredients. They distinguish their liqueurs as "eaux" and "extraits," or liqueurs which, though sweetened, are entirely devoid of viscidity; and "baumes," "crêmes," and "huiles," which contain sufficient sugar to impart to them a syrupy consistence; usually "crêmes" contain less alcohol than "huiles." The greatest possible attention is given to the preparation of the aromatized or flavouring essences, in France called "infusions." These are generally made by macerating the aromatic ingredients in spirit at about 2 to 4 u. p. (sp. gr. ·922 to ·925), placed in well-corked glass carboys, or stone-

ware jars or bottles. The maceration is continued, with occasional agitation, for three, four, or even five weeks, when the aromatized spirit is either distilled or filtered; generally the former. The outer peel of cedrats, lemons, oranges, limettes, bergamottes, &c., is alone used by our Continental neighbours, and is obtained either by carefully peeling the fruit with a knife, or by "oleo-saccharum," which is made by rubbing the peel with a lump of hard white sugar. Aromatic seeds and woods are bruised before being submitted to infusion. The substances employed in France to colour liqueurs are, for:—*blue*, sulphate of indigo nearly neutralized with chalk, and the juice of blue flowers and berries;—*amber*, *fawn*, and *brandy colour*, burnt sugar or spirit colouring;—*green*, spinach or parsley leaves digested in spirit, and mixtures of *blue and yellow*;—*red*, powdered cochineal or brazil wood, either alone or mixed with a little alum;—*violet*, blue violet petals, litmus, or extract of logwood;—*purple*, the same as violet, only deeper;—*yellow*, an aqueous infusion of safflower or French berries, and the tinctures of saffron and turmeric.

A frequent cause of failure in the manufacture of liqueurs and cordials is the addition of too much flavouring matter. Persons unaccustomed to the use of strong aromatic essences and essential oils seldom sufficiently estimate their power, and, consequently, are very apt to add too much of them, by which the liqueur is rendered not only disagreeably high flavoured, but, from the excess of oil present, also milky, or foul, either at once, or what is nearly as bad, on the addition of water. This source of annoyance, arising entirely from bad manipulation, frequently discourages the tyro, and cuts short his career as a manufacturer. From the viscidity of cordials they are less readily fined down than unsweetened liquids, and often give much trouble to clumsy and inexperienced operators. The most certain

way to prevent disappointment in this respect is to use too little rather than too much flavouring; for if the quantity prove insufficient, it is readily "brought up" at any time, but the contrary is not effected without some trouble and delay.

A careful attention to the previous remarks will render this branch of the rectifier's art far more perfect and easy of performance than it is at present, and will, in most cases, produce at once a satisfactory article, fine, sweet, and pleasant.

The cordials of respectable British compounders contain fully 3 lbs. of white lump sugar per gallon, and are of the strength of 60 to 64 u. p. The *baumes*, *crêmes*, and *huiles* imported from the Continent are richer both in spirit and sugar than ours, and to this may be referred much of their superiority. Mere sweetened or cordialized spirits (*eaux* of the French liqueurists) contain only from 1 to 1½ lb. of sugar per gallon.

The following list embraces the chief cordials and liqueurs, both native and imported, met with in trade in this country:—

Absinthe. — *Syn.* EXTRAIT D'ABSINTHE DE SUISSE; SWISS EXTRACT OF WORMWOOD.—1. From the tops of *Absinthium majus*, 4 lbs.; tops of *Absinthium minus*, 2 lbs.; angelica root, *Calamus aromaticus*, Chinese aniseed, and leaves of dittany of Crete, of each 15 grs.; brandy or spirit at 12 u. p., 4 galls.; macerate for ten days, then add water, 1 gall.; distil 4 galls. by a gentle heat, and dissolve in the distilled spirit crushed white sugar, 2 lbs. 2. Spirit of wormwood, 172 parts; best sugar, 125 parts; orange flour water, 13½ parts; water, 125 parts. Dissolve the sugar in the water, and then add the orange-flower water; thoroughly mix in the syrup the white of one egg. Next add the wormwood spirit, and heat the mixture very

gently over a water-bath, so as just to coagulate the albumen; immediately remove the liquid from the fire and filter. A French writer says the ordinary absinthe sold in France is a mixture of aromatic plants and sulphuric acid, coloured with spinach. According to Dr. Decaisne, it also contains another very dangerous ingredient—viz., antimony.

Alkermes.—This liqueur is highly esteemed in some parts of the South of Europe.

1. Bay leaves and mace, of each 1 lb.; nutmegs and cinnamon, of each 2 oz.; cloves, 1 oz., all bruised; cognac brandy, $3\frac{1}{2}$ galls.; macerate for three weeks, frequently shaking, the distil over 3 galls., and add of clarified spirit of kermes, 18 lbs.; orange-flower water, 1 pint; mix well and bottle. This is the original formula for the "Alkermes de Santa Maria Novella," which is much valued.

2. Spice, as last; British brandy, 4 galls.; water, 1 gall.; macerate as before, and draw over 4 galls., to which add, of syrup, 2 galls., and sweet spirit of nitre, $\frac{1}{4}$ pint. Cassia is often used for cinnamon. Inferior to the last.

Aniseed Cordial.—1. From aniseed, 2 oz., or essential oil, $1\frac{1}{2}$ dr., and sugar, 3 lbs. per gall. It should not be weaker than about 45 u. p., as at lower strengths it is impossible to produce a full-flavoured article without its being milky, or liable to become so.

2. (ANISETTE DE BORDEAUX.)—1. (*Foreign.*) Aniseed, 4 oz.; coriander and sweet fennel seeds, bruised, of each 1 oz.; rectified spirit, $\frac{1}{2}$ gall.; water, 3 quarts; macerate for five or six days, then draw over 7 pints, and add of lump sugar, $2\frac{1}{2}$ lbs. 2. (*English.*) Oil of aniseed, 15 drops; oils of cassia and caraway, of each 6 drops; rub them with a little sugar, and then dissolve in spirit (45 u. p.), 3 quarts, by well shaking them together;

filter, if necessary, and dissolve in the clear liquid, 1½ lb. of sugar.

Balm of Molucca.—From mace, 1 dram; cloves, ½ oz.; clean spirit (22 u. p.), 1 gall.; infuse for a week in a well-corked carboy or jar, frequently shaking, colour with burnt sugar q. s., and to the clear tincture add 4½ lbs. of lump sugar; dissolve in pure soft water, ½ gall. On the Continent this takes the place of the cloves of the English retailer.

Bitters.—These have generally from 1 to 1½ lb. of sugar per gallon.*

Brandy, Caraway.—A species of cordial commonly prepared as follows:—1. Bruised caraway-seeds, 4 oz; lump sugar, 2 lbs.; British brandy, 1 gall.; macerate a fortnight, occasionally shaking the bottle. 2. Sugar, 1 lb.; bruised caraways, 1 oz.; 3 bitter almonds, grated; spirit colouring, 1 oz.; plain spirit or gin (22 u. p.), ½ gall. Infuse, &c., as BALM OF MOLUCCA. The colouring is sometimes left out.

Brandy, Cherry.—1. Brandy and cherries crushed, of each 1 gall.; let them lie together for 3 days, then express

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* "Bitters" are a compound prepared by steeping vegetable bitters, and some aromatics as flavouring, in weak spirit, for some eight or ten days; a little sugar or syrup being subsequently added to the strained or decanted tincture. In that of the taverns and gin-shops the menstruum is usually gin, or plain spirit reduced to a corresponding strength. BRANDY-BITTERS and WINE-BITTERS are prepared in a similar way with common British brandy, or some cheap white wine, such as raisin. Each maker has usually his own formulæ, which he modifies to suit the price and the palate of his customer. This class of liquor has been justly charged with being the fertile cause of habitual intemperance and of disease. Their occasional use as tonics or stomachics is also objectionable, owing to the trash, and even deleterious substances, which so frequently enter into their composition.

the liquid, and add 2 lbs. of lump sugar; in a week or two decant the clear portion for use.

2. To the last add 1 quart of raspberry juice, and ½ a pint of orange-flower water. Both the above are excellent.

3. Treacle, 1 cwt.; spirit (45 u. p.), 41 galls.; bitter almonds bruised, 1 lb. (more or less to taste); cloves, 1 oz.; cassia, 2 oz.; macerate a month, frequently stirring. An article frequently sold as cherry brandy.

4. German cherry juice, 15 galls.; pure rect. spirit, 20 galls.; syrup, 5 galls.; oil of bitter almonds, 1 dram.

Equal parts of fully ripe Morello cherries and black cherries produce the richest cherry brandy. Some persons prick each cherry separately with a needle instead of crushing them; in which case they retain them in the liquid, and serve up a few of them in each glass. The plan named in the first formula is, however, that usually adopted. On the small scale, the fruit is commonly bruised between the fingers. A small portion only of the stones in the cherries should be crushed, to impart a nutty flavour.

Brandy, Lemon.—1. Fresh lemons sliced, 1 dozen; brandy, 1 gall.; macerate for a week, press out the liquid, and add of lump sugar, 1 lb.

2. Proof spirit, 7 galls.; essence of lemon, 3 drams; sugar, 5 lbs.; tartaric acid, 1 oz., dissolved in water, 2 galls.; turmeric powder or spirit colouring, a dessertspoonful; macerate, &c., as No. 1. Sometimes boiling milk is added to the above, in the proportion of 1 quart to every gallon.

Brandy, Orange.—As lemon brandy, but substituting oranges.

Brandy, Peach.—From peaches, by fermentation and distillation. Much used in the United States, where peaches are very plentiful, and consequently cheap. A cordial spirit under the same name is prepared as follows:—

1. From peaches, sliced and steeped in twice their weight

of British brandy or malt-spirit, as in making cherry brandy.

2. Bitter almonds bruised, 3 oz.; proof spirit, 10 galls.; water, 3 galls.; sugar, 5 or 6 lbs.; orange-flower water, ½ a pint; macerate for fourteen days. Add brandy-colouring, if required darker.

Raspberry Brandy.—From raspberries, using the proportion given under CHERRY BRANDY. Sometimes a little cinnamon and cloves are added. The only addition, however, that really improves the flavour or bouquet is a little orange-flower water, a very little essence of vanilla, or a single drop of essence of ambergris.

Brandy, Shrub.—Brandy, 1 gallon; orange and lemon juice, of each 1 pint; the peel of 2 oranges; do. of 1 lemon; digest for twenty-four hours; strain, and add of white sugar, 4 lbs., dissolved in water, 5 pints. After a fortnight, decant the clear liquid for use.

Caraway Cordial.—This is generally made from the essential oil of caraway, with 2½ lbs. of sugar per gall. 1 fl. dram of the oil is commonly reckoned equal to ¼ lb. of the seed. The addition of a very little oil of cassia, and about half as much of essence of lemon or of orange, improves it.

Cedrat Cordial.—From essence (oil) of cedrat, ¼ oz.; pure spirit (at proof), 1 gall.; dissolve, add of water, 3 pints, agitate well; distil 3 quarts, and add an equal measure of clarified syrup. A delicious liqueur. *See* CRÊME and EAU, further on.

Grande Chartreuse.—This renowned liqueur, made by the monks of the Monastery of the Grande Chartreuse, near Grenoble, is said to have the following composition:—Essence of balm (flavoured with lemon), 31 grains; essence of hyssop, 31 grains; essence of angelica, 2½ drms.; essence of English peppermint, 5 drms.; essence of nutmeg, 36 grains

essence of cloves, 31 grains; rectified alcohol, 3½ pints; sugar, q. s.; the whole being coloured yellow or green, according to taste. Another writer states that it is composed of carnations, wormwood, and the young buds of the pine tree, and that there are three kinds:—white, yellow, and green, each differing in strength.

Cinnamon Cordial.—This is seldom made with cinnamon, owing to its high price, but either with the essential oil or bark of cassia, with about 2 lbs. of sugar to the gall. It is preferred coloured, and therefore may be very well prepared by simple digestion. The addition of 5 or 6 drops each of essence of lemon and orange peel, with about a spoonful of essence of cardamoms per gall., improves it. 1 oz. of oil of cinnamon is considered equal to 8 lbs. of the buds or bark. 1 fl. dram of the oil is enough for 2½ galls. It is coloured with burnt sugar.

Citron Cordial.—From the oil or peel, with 3 lbs. of sugar per gall., as above.

Citronelle.—*Syn.* Eau de Barbades.

1. From fresh orange peel, 2 oz.; fresh lemon peel, 4 oz.; cloves, ½ dram; corianders and cinnamon, of each 1 dram; proof spirit, 4 pints; digest for ten days; then add of water, 1 quart, and distil ½ gall.; to the distilled essence add of white sugar, 2 lbs., dissolved in water, 1 quart.

2. Essence of orange, ½ dram; essence of lemon, 1 dram; oil of cloves and cassia, of each 10 drops; oil of coriander, 20 drops; spirit (58 o. p.), 5 pints; agitate until dissolved, then add of distilled or clear soft water, 3 pints; well mix, and filter it through blotting paper, if necessary; lastly add of sugar dissolved in water, q. s.

Clairet. — *Syn.* Rossolis des Six Graines. 1. From aniseed, fennel seed, coriander seed, caraway seed, dill seed, and seeds of the candy-carrot (*Athamantia cretensis*—Linn.), of each, bruised, 1 oz.; proof spirit, ½ gall.; digest for a week,

strain, and add of loaf sugar, 1 lb., dissolved in water, q. s.
2. (EAU-CLAIRETTE) another very old French form was, 3 oz. cinnamon, eau de vie, 1 pint, to which was added sugar and rose water.

Cloves. — *Syn.* CLOVE CORDIAL. From bruised cloves, 1 oz., or essential oil, 1 fl. dram, to every 3 gallons of proof spirit. If distilled, some common salt should be added, and it should be drawn over with a pretty quick fire. It requires fully 3 lbs. of sugar per gall., and is generally coloured with red poppy flowers or burnt sugar. The addition of 1 dram of bruised pimento, or 5 drops of the oil for every ounce of cloves, improves this cordial. *See* BALM OF MOLUCCA (*ante*).

Coriander Cordial.—From coriander seeds, as CLOVES. A few sliced oranges improve it.

Crême d'Anis.—As ANISEED CORDIAL, only richer.

Crême des Barbades.—As CITRONELLE, adding some of the juice of the oranges, and an additional pound of sugar per gall.

Crême de Cacao.—Infuse roasted Caracca-cacao nuts cut small, 1 lb., and vanilla, $\frac{1}{2}$ oz., in brandy, 1 gall., for eight days; strain, and add of thick syrup, 3 quarts.

Crême de Cedrat.—*Syn.* HUILE DE CEDRAT. From spirit of citron, 1 pint; spirit of cedrat, 1 quart; proof spirit, 3 quarts; white sugar, 16 lbs., dissolved in pure soft water, 2 galls.

Crême de Macarons.—1. From cloves, cinnamon, and mace, of each bruised, 1 dram; bitter almonds, blanched and beaten to a paste, 7 oz.; spirit (17 u. p.) 1 gall.; digest a week, filter, and add of white sugar, 6 lbs., dissolved in pure water, 2 quarts.

2. Clean spirit (at 24 u. p., sp. gr. ·945), 2 galls.; bitter almonds, $\frac{3}{4}$ lb.; cloves, cinnamon, and mace, of each in coarse powder, $1\frac{1}{2}$ drams; infuse for ten days, filter, and add of white sugar, 8lbs. dissolved in pure water, 1 gall.; lastly, give the

liqueur a violet tint with infusion or tincture of litmus and cochineal. An agreeable, nutty-flavoured cordial, but, from containing so many bitter almonds, should be only drunk in small quantities at a time. The English use only one-half the above quantity of almonds.

Crême de Naphe.—From sweetened spirit (60 u. p.) containing $3\frac{1}{2}$ lbs. of sugar per gall., 7 quarts; foreign orange-flower water, 1 quart. Very delicious.

Crême de Noyau.—*See* NOYEAU.

Crême d'Orange. — From sliced oranges, 3 dozen; rectified spirit, 2 galls.; digest for fourteen days; add, of lump sugar, 28 lbs. (previously dissolved in water), $4\frac{1}{2}$ galls.; tincture of saffron, $1\frac{1}{2}$ fl. oz.; and orange-flower water, 2 quarts.

Crême de Portugal.—Flavoured with lemon, to which a little oil of bitter almonds is added.

Curaçoa.—From sweetened spirit (at 56 u. p.), containing $3\frac{1}{2}$ lbs. of sugar per gall., flavoured with a tincture made by digesting the "oleo-saccharum" prepared from Seville oranges, nine in number; cinnamon, 1 dram; and mace, $\frac{3}{4}$ dram in rectified spirit, 1 pint. It is coloured by digesting in it for a week or ten days, Brazil-wood in powder, 1 oz., and afterwards mellowing the colour with burnt sugar, q. s.

Delight of the Mandarins.—From spirit (22 u. p.), 1 gall.; pure soft water, $\frac{1}{2}$ gall.; white sugar crushed small, $4\frac{1}{2}$ lbs.; Chinese aniseed and ambrette or musk seed, of each, bruised, $\frac{1}{2}$ oz.; safflower, $\frac{1}{4}$ oz.; digested together in a carboy or stone bottle capable of holding double, and agitated well every day for a fortnight.

Eau de Cedrat.—*Syn.* CEDRAT WATER. As CRÊME DE CEDRAT, but using less sugar.

Eau de Chasseurs.—*See* PEPPERMINT, further on.

Eau de Vie d'Andaye.—*Syn.* EAU DE VIE D'ANIS;

ANISEED LIQUEUR BRANDY; LIQUEUR D'HENDAYE. From brandy or proof spirit, 1 gall.; sugar, $\frac{3}{4}$ lb.; dissolved in aniseed water, 1 pint. This is sometimes flavoured with fennel.

Essence of Orange Peel.—(GOLDEN.) Fresh yellow rind of orange, 4 oz.; rectified spirit and water, of each $\frac{1}{2}$ pint; digest for a week, press, filter, and add of sherry 1 quart. A pleasant liqueur.

Gold Cordial.—*Syn.* EAU DE DANTZIG. From angelica root sliced, 1 lb.; raisins, $\frac{1}{2}$ lb.; coriander seeds, 2 oz.; caraway seeds and cassia, of each $1\frac{1}{2}$ oz.; cloves, $\frac{1}{2}$ oz.; figs and sliced liquorice root, of each 4 oz.; proof spirit, 3 galls.; water, 1 gall.; digest 2 days, and distil 3 gallons by a gentle heat; to this add, of sugar, 9 lbs., dissolved in rose water and clean soft water, of each 1 quart; lastly, colour the liquid by steeping in it $1\frac{1}{4}$ oz of hay saffron. This cordial was once held in much esteem for its supposed medicinal virtues, the formula being mentioned by ARNOLD DE VILLENEUVE. It derives its name from a small quantity of gold leaf being formerly added to it, which was supposed to add greatly to its remedial value. Until comparatively recent years, gold was credited with extraordinary remedial powers.

Huile d'Anis.—*See* CRÊME D'ANIS (*ante*).

Huile d'Annanas.—Five oz. of rasped pine-apple are macerated in 15 oz. of spirits of wine for 15 or 20 days, at the end of which time the liquid is decanted and filtered. It is then well shaken up with 15 oz., by weight, of clear syrup.

Huile Liqueureuse.—1. (DE LA ROSE.) From eau de rose, 1 part; simple syrup, 2 parts; mixed together.

2. (DES FLEURS D'ORANGE.)—From orange flower water and syrup, as No. 1.

3. (DE VANILLE.)—From essence of vanilla, 1 dram; simple syrup, 1 pint.

The above are kept in small decanters, and used to flavour water, grog, liqueurs, &c., instead of sugar or capillaire; also to perfume the breath. Other flavoured syrups, for the same purposes, are prepared in a similar manner.

Huile de Vanille.—Flavoured with essence or tincture of vanilla. It is kept in a decanter, and used to flavour liqueurs, grog, &c.

Huile de Vénus.—From the flowers of the wild carrot, $2\frac{1}{2}$ oz., and sugar, 3 lbs. to the gall. It is generally coloured by infusing a little powdered cochineal in it.

Jargonelle. — *Syn.* JARGONELLE CORDIAL. Flavoured with essence of jargonelle pear (acetate of amyl). Pine-apple cordial and liqueurs from some other fruits are also prepared from the artificial fruit essences.

Kirschwasser.—A spirituous liquid distilled in Germany and Switzerland from bruised cherries. From the rude manner in which it is obtained, and from the distillation of the cherry-stones (which contain prussic acid) with the liquid, it has often a nauseous taste, and is frequently poisonous. When properly made and sweetened it resembles noyeau. *See* page 154.

Lemon Cordial.—Digest fresh and dried lemon peel, of each 2 oz., and fresh orange peel, 1 oz., in proof spirit, 1 gall., for a week; strain with expression, add of clear soft water q. s. to reduce it to the desired strength, and lump sugar, 3 lbs. to the gallon. The addition of a little orange-flower or rose-water improves it.

Liquodilla.—Flavoured with oranges and lemons, of each, sliced, 3 in number; with sugar $2\frac{1}{2}$ lbs. per gall.

Lovage Cordial.—From the fresh roots of lovage, 1 oz. to the gallon. A fourth of this quantity of the fresh roots of celery and sweet fennel are also commonly added. In some parts a little fresh valerian root and oil of savine are added before distillation. This cordial is much valued by the lower

classes in some of the provinces for its stomachic and emmenagogue qualities.

Maraschino. — *Syn.* MARASQUIN. A delicate liqueur spirit distilled from a peculiar cherry growing in Dalmatia, and afterwards sweetened with sugar. The best is from Zara, and is obtained from the marasca cherry only. In the middle of the last century the profits arising from the sale of this compound were so considerable that the Senate of Venice, where it was principally manufactured, monopolized the trade in it. An inferior quality is distilled from a mixture of cherries and the juice of liquorice root.

Nectar.—The fabled drink of the mythological deities. The name was formerly given to wine dulcified with honey; it is now occasionally applied to other sweet and pleasant beverages of a stimulating character. The following LIQUEUR is so called:—

Chopped raisins, 2 lbs.; loaf sugar, 4 lbs.; boiling water, 2 galls.; mix and stir frequently until cold, then add 2 lemons, sliced; proof spirit, brandy, or rum, 3 pints; macerate in a covered vessel for 6 or 7 days, occasionally shaking, next strain with pressure, and let the strained liquid stand in a cold place for a week to clear; lastly decant the clear portion and bottle it.

Noyau.—*Syn.* CRÊME DE NOYAU. This is a pleasant nutty-tasted liqueur; but, from the large proportion of prussic acid which it contains, it should be partaken of very moderately.

1. Bitter almonds bruised, 3 oz.; spirit (22 u. p.) 1 quart; sugar, 1 lb.; (dissolved in) water, $\frac{3}{4}$ pint; macerate for 10 days, frequently shaking the vessel; then allow it to repose for a few days, and decant the clear portion.

2. As the last, but substituting apricot or peach kernels with the bruised shells, for the almonds.

3. To either of the above, add of coriander seed and

ginger, of each, bruised, 1 dram; mace and cinnamon, of each ½ dram.

4. (Crême de Noyau de Martinique.) Loaf sugar, 14 lbs.; water, 2½ galls.; dissolve, add, of proof spirit, 5 galls.; orange-flower water, 3 pints; bitter almonds bruised, 1 lb.; essence of lemons, 2 drams.

Oil of Cedrat.—*See* Crême de Cedrat (*ante*).

Orange Cordial.—Like Lemon Cordial or Crême d'Orange, from fresh orange peel, ½ lb. to the gallon.

Parfait Amour.—*Syn.* Perfect Love. 1. Flavoured with the yellow rind of 4 lemons, and a teaspoonful of essence of vanilla to the gallon, with sugar, 3 lbs., and powdered cochineal q. s. to colour.

2. Sugar, 8½ lbs.; spirit of wine, 5½ lbs.; dissolved in 6 lbs. of water; essence of cloves, 1¼ oz.; essence of mace, 3 drams; essence of lemon, 1 dram; coloured rose.

Peppermint.—*Syn.* Peppermint Cordial, Sportsman's Cordial; Eau de Chasseurs. This well-known compound is perhaps in greater demand in every part of the kingdom than all the other cordials put together.

Prep. 1. From peppermint water and gin or plain spirit (22 u. p.), of each 1 pint; lump sugar, ¾ lb.

2. (Wholesale.) English oil of peppermint, 5 oz., is added to rectified spirits of wine, 3 pints, and the mixture is agitated well together for some time in a corked bottle capable of holding 4 pints or more; it is then emptied into a cask having a capacity of upwards of 100 galls., and 36 galls. of perfectly white and flavourless proof spirit is poured in, and the whole well agitated for ten minutes; a solution of the best double refined lump sugar, 2¾ cwts., in about 35 galls. of pure filtered rain water, is then added, and the contents of the cask well rummaged up in the usual manner for at least 15 minutes; sufficient clear rain water to make up the whole quantity to exactly 100 gallons, and

holding in solution 5 oz. of alum, is next added, and the whole is again well agitated for at least a quarter of an hour, after which the cask is bunged down, and allowed to repose for a fortnight before it is broached for sale.

The last formula produces a beautiful article, provided the ingredients are of good quality. Care on this point is particularly necessary in reference to the essential oil, which should only be purchased of some known respectable dealer. The sugar should be sufficiently pure to dissolve in a wine-glassful of clear soft water without injuring its transparency, and the cask should be a freshly-emptied gin pipe, or one properly prepared for gin, as, if it gives colour, it will spoil the cordial. When these particulars are attended to, the product is a bright transparent liquid as soon as made, and does not require fining. Should there be the slightest opacity, the addition of 2 oz. of salt of tartar, dissolved in a quart of hot water, will have the effect of clearing it down in the course of a few days. The product is 100 galls. of cordial at 64 u. p.

Pimento. — *Syn.* PIMENTO CORDIAL, PIMENTO DRAM. Rather strongly flavoured with allspice or pimento. It has obtained a great repute in the West Indies in diarrhœa, cholera, and bowel complaints generally.

Raspberry Cordial.—From raspberry brandy, syrup, and water, equal parts. A similar article is prepared by flavouring sweetened spirit with the artificial raspberry essence.

Ratafia.—Originally a liqueur drunk at the ratification of an agreement or treaty. It is now the common generic name in France of liqueurs compounded of spirit, sugar, and the odoriferous and flavouring principles of vegetables, more particularly of those containing the juices of recent fruits, or the kernels of apricots, cherries, or peaches. In its restricted sense this name is commonly understood as referring to cherry-brandy or peach-brandy.

The following list includes those Ratafias which are commonly prepared by the French liqueurists:—

Ratafia d'Angélique.—From angelica seeds, 1 dr.; angelica stalks, 4 oz.; blanched bitter almonds, bruised, 1 oz.; proof spirit or brandy, 6 quarts; digest for 10 days, filter; add, of water, 1 quart; white sugar, $3\frac{1}{2}$ lbs.; mix well, and in a fortnight decant the clear portion through a piece of clean flannel.

Ratafia d'Anis.—*See* ANISEED CORDIAL (*ante*).

Ratafia de Baume de Tolu.—From balsam of Tolu, 1 oz.; rectified spirit, 1 quart; dissolve, add water, 3 pints; filter, and further add of white sugar, $1\frac{1}{2}$ lb.

Ratafia de Brou de Noix.—From young walnuts with soft shells pricked or pierced, 60 in number; brandy, 2 quarts; mace, cinnamon, and cloves, of each 15 grs.; digest for 8 weeks; press, filter, add of white sugar, 1 lb.; and keep it for some months before decanting it for use.

Ratafia de Cacao.—*Syn.* RATAFIA DE CHOCOLAT.—From Caracca cacao-nuts, 1 lb.; West Indian do., $\frac{1}{2}$ lb., both roasted and bruised, proof spirit, 1 gall.; digest for 14 days, filter, and add, of white sugar, $2\frac{1}{2}$ lbs.; tincture of vanilla, $\frac{1}{2}$ dram (or a shred of vanilla may be infused with the nuts in the spirit instead); lastly, decant in a month, and bottle it.

Ratafia de Café.—1. From coffee, ground and roasted, 1 lb.; brandy or proof spirit, 1 gall.; sugar, 2 lbs. dissolved in water, 1 quart; as last. 2. Coffee, 1 lb.; brandy, $6\frac{1}{4}$ lbs.; macerate the coffee in the brandy for 7 or 8 days, and then distil over a water bath, and to the distillate add a very clear syrup, made by dissolving $2\frac{1}{2}$ lbs. of the best sugar in 4 lbs. of water. This liqueur has all the aroma and none of the bitterness of the coffee.

Ratafia de Cassis.—From black currant juice, 1 quart; cinnamon, 1 dram; cloves and peach kernels, of each $\frac{1}{2}$ dram;

brandy, 1 gall.; white sugar, 3lbs.; digest for a fortnight, and strain through flannel.

Ratafia de Cerise.—From Morello cherries, with their kernels, bruised, 8 lbs.; brandy or proof spirit, 1 gall.; white sugar, 2 lbs.; as last.

Ratafia de Chocolat.—Ratafia de cacao (*see ante*).

Ratafia de Coings.—From quince juice, 3 quarts; bitter almonds, 3 drams; cinnamon and coriander seeds, of each 2 drams; mace, ½ dram; cloves, 15 grs. all bruised; rectified spirit, quite flavourless, ½ gall.; digest for a week, filter, and add of white sugar, 3½ lbs.

Ratafia de Crême.—From crême de noyeau and sherry, of each ¼ pint; syrup, ½ pint; fresh cream, 1 pint; beaten together.

Ratafia de Curaçoa.—*See* Curaçoa (*ante*).

Ratafia de Framboises.—*Syn.* Raspberry Cordial. To 1¼ lb. of raspberry juice add ¼ lb. of cherry juice; boil this with 2 lbs. of sugar; add 4 pints of brandy, and let it macerate for a fortnight; filter.

Ratafia de Genièvre.—From juniper berries, each pricked with a fork, ¼ lb.; caraway and coriander seed, of each 40 grs.; finest malt spirit (22 u. p.), 1 gall.; white sugar, 2 lbs.; digest a week, and strain with expression.

Ratafia de Grenoble.—From the small wild black cherry with the kernels bruised, 2 lbs.; proof spirit, 1 gall.; white sugar, 3 lbs.; citron peels, a few grains; as before.

Ratafia de Grenoble, de Teyssère.—From cherries, bruised with the stones, 1 quart; rectified spirit, 2 quarts; mix, digest for 48 hours, then express the liquid, and heat it to boiling in a close vessel; when cold, add of sugar or syrup, q. s., together with some noyeau, to flavour, and a little syrup of the bay laurel, and of galangal; in 3 months decant, and bottle it.

Ratafia de Noyau.—From peach or apricot kernels,

bruised, 120 in number; proof spirit or brandy, 2 quarts; white sugar, 1 lb.; digest for a week, press, and filter.

Ratafia d'Œillets. — From clove-pinks without the white buds, 4 lbs.; cinnamon and cloves, of each 15 grs.; proof spirit, 1 gall.; macerate for ten days, express the tincture, filter, and add of white sugar, 2½ lbs.

Ratafia d'Ecorce d'Orange.—CRÊME D'ORANGE (*see ante*).

Ratafia de Fleurs d'Orange.—From fresh orange petals, 2 lbs.; proof spirit, 1 gall.; white sugar, 2½ lbs.; as last. Instead of orange flowers, 1 dram of oil of neroli may be used.

Ratafia à la Provençale.—From striped pinks, 1 lb.; brandy or proof spirit, 1 quart; white sugar, ¾ lb.; juice of strawberries, ¾ pint; saffron, 20 grs.; as before.

Ratafia des Quatre Fruits.—From cherries, 30 lbs.; gooseberries, 15 lbs.; raspberries, 8 lbs.; black currants, 7 lbs.; express the juice, and to each pint add, of white sugar, 6 oz.; cinnamon, 6 grs.; cloves and mace, of each 3 grs.

Ratafia Rouge.—From the juice of black cherries, 3 quarts; juices of strawberries and raspberries, of each 1 quart; cinnamon, 1 dram; mace and cloves, of each 15 grs.; proof spirit or brandy, 2 gall.; white sugar, 7 lbs.; macerate, &c., as before.

Ratafia Sec.—Take of the juice of gooseberries, 5 pints; juices of cherries, strawberries, and raspberries, of each 1 pint; proof spirit, 6 quarts; sugar, 7 lbs.; as before.

Ratafia à la Violette.—From orris powder, 3 oz.; litmus, 4 oz.; rectified spirit, 2 galls.; digest for ten days, strain, and add of white sugar, 12 lbs.; dissolved in soft water, 1 gall.

Rosoli.—Rose leaves, 8¾ oz.; orange-flower water, 4

pints; Ceylon cinnamon, 124 grs.; cloves, 1 oz.; macerate the rose leaves, the cinnamon, and the cloves in $17\frac{1}{2}$ pints of spirit, and distil; and to the distillate add 15 oz. of sugar dissolved in 4 pints of orange-flower water.

Shrub.—*See* SHRUB and RUM SHRUB.

Sighs of Love.—1. From proof spirit (flavoured with otto of roses) and syrup in equal parts.

2. From sugar, 6 lbs., pure soft water, q. s. to produce a gallon of syrup, to which add, of eau de rose, 1 pint; proof spirit, 7 pints. It is coloured a pale pink by powdered cochineal. A very pleasant cordial. A drop or two, not more, of essence of ambergris or vanilla improves it.

Tears of the Widow of Malabar.—As BALM OF MOLUCCA, but employing cloves bruised, $\frac{1}{2}$ oz., mace shredded, 1 dram, and a teaspoonful of essence of vanilla for flavouring; $\frac{1}{4}$ pint of orange-flower water is sometimes added. It is slightly coloured with burnt sugar.

Usquebaugh.—*Syn.* ESCUBAC. Literally, "mad water," the Irish name of which, "whisky," is a corruption. It is applied to a strong cordial spirit, much drunk in Ireland, and made in the greatest perfection at Drogheda.

1. Brandy or proof spirit, 3 galls.; dates without their kernels, and raisins, of each, bruised, $\frac{1}{4}$ lb.; juniper berries, bruised, 1 oz.; mace and cloves, of each $\frac{3}{4}$ oz.; coriander and aniseed, of each $\frac{1}{2}$ oz.; cinnamon, $\frac{1}{4}$ oz.; macerate, with frequent agitation, for 14 days, then filter, and add of simple syrup, 1 gall.

2. Pimento and caraways, of each 3 oz.; mace, cloves, and nutmegs, of each 2 oz.; aniseed, corianders, and angelica root, of each 8 oz.; raisins, stoned, and bruised, 14 lbs.; proof spirit, 9 galls.; digest as before, then press, filter, or clarify, and add of simple syrup, q. s. Should it turn

milky, add a little strong spirit, or clarify it with alum, or filter through magnesia.

Usquebaugh is either coloured yellow with saffron (about $\frac{1}{4}$ oz. per gall.), or green with sap-green (about $\frac{1}{2}$ oz. per gall.); either being added to the other ingredients before maceration in the spirit.

CHAPTER V.

DISTILLATION OF ALCOHOLIC LIQUORS.

THE process of distillation, as carried on in the distilleries of Great Britain, may be divided into four general operations, viz.:—1. The mashing, or formation of a saccharine infusion from certain vegetable matters, as malt, barley, oats, rye, wheat, &c. 2. The cooling of this wort or liquid. 3. The fermentation, or process by which the sugar of the cooled wort is converted into alcohol. 4. The separation of the spirit so formed by means of a still and refrigerator. By the first operation the materials for the formation of the alcohol are obtained; by the second, they are brought to a temperature most favourable to the transformation that takes place in the third, after which it only remains to free the product of the last operation from the foreign matter with which it is associated; this is done in the fourth, which, correctly speaking, constitutes the only part of the process which can be called distillation.

The general principles of the first three of the preceding operations are noticed in the article BREWING. It will there be seen that the amylaceous or starchy matter of the grain is first saccharified, and afterwards converted into alcohol, and that certain precautions are necessary to render the process successful and economical. In some of the distilleries of Great Britain molasses and analogous saccharine substances are employed, in which case the principle essential to the formation of alcohol—viz., sugar, is already present,

and merely requires simple solution in water of a proper temperature, to be ready to be subjected to immediate fermentation. In general, however, the sources of spirit in England are the various kinds of grain; barley, rye, maize, and rice are those commonly employed. These are ground and mixed with bruised malt, in various proportions, and are mashed in a similar manner to malted grain.*

By some distillers malted grain alone is preferred, as it is believed to yield a larger quantity of spirit, with greater facility and in less time. It possesses, however, the disadvantage of being costlier than the unmalted. Others use a mixture of the two in proportions (when malt, and raw grain are employed) varying in different distilleries from one part of the former to two, three, four, five, six, eight, ten, and even fifteen parts of the latter. By the Scotch distillers the proportions used are 40 bushels of barley, 20 of malt, and 700 or 800 wine gallons of water, run into the mash-tun at a temperature of 150° Fahr., the mixture being kept in agitation by machinery.

This operation varies from one to four hours, the larger the quantity of raw grain used, the longer being the time required for mashing. The temperature of the mixture is kept up by the addition to it from time to time of about 500 gallons of water, at a temperature of from 190° to 205° Fahr.†

* In many of the large distilleries, and in some of the small ones, maize and rice are used without any malt. They are converted by mashing with sulphuric acid, and neutralizing with chalk.

† As the wort rapidly runs into the acetous fermentation, the distiller guards against this by reducing it as quickly as possible to the temperature at which it should undergo fermentation (from 60° to 64° Fahr.) This he does by pumping the wort from the *underback* into the coolers, where the yeast is added. The old-fashioned method of cooling worts was by running them into shallow wooden vessels, so as to expose a large surface of liquid to a draught of cold air, but as this process involved a large waste of alcohol, arising from

According to Dr. Thompson, a considerable quantity of starch remains unaltered, but the wort gradually increases in sweetness from the beginning to the close of the operation, and is drawn off at the bottom of the mash-tub as in brewing. The quantity of wort is about one-third of the whole quantity of water used—that is, the 1,200 gallons will have yielded about 400. To prevent the loss of the remaining two-thirds of wort about 500 gallons of water at 190° Fahr., are run upon the residue left in the mash-tun, and the whole being well mixed, is allowed to stand for one and a half hours, and the liquid portion then drawn off. 800 gallons of fresh water are then run into the mash-tub upon the sedimentary grains, and the mixture being well stirred, is left to stand for half an hour or forty minutes. The resulting weak wort is either used for mashing a fresh quantity of grist, or being concentrated by boiling to the requisite strength, is added to the first or second worts in the fermenting vessel. By some distillers a fourth mash is made with boiling water, and used instead of water in the next day's brewing. When barley, malt, and oats are employed, two or three parts of malt and one of oats give a satisfactory product; when the oat predominates it imparts a peculiar flavour to the resulting spirit. When the unmalted grain is in large excess, chaff is sometimes added to the grist. When rye is used, one part to two or three parts of malted grain may be taken. The Russians and Swedes obtain a spirit wholly from unmalted rye. Furthermore, whatever be the grain employed, it is essential that it should be well ground and crushed previous to being mashed, the unmalted requiring to be reduced to a finer powder than the malted.*

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evaporation, it has been lately almost universally abandoned, and the worts are now cooled by being made to traverse pipes immersed in cold running water.

* Muspratt.

The fermentation is carried on until the density of the liquid ceases to lessen or attenuate, which is determined by an instrument called a saccharometer. When this point is arrived at, the wash is submitted to distillation. During the fermentation, which varies with the season, and according to temperature, from four to nine days, the fermenting vats are freely exposed to the air, at first for a few days, but are afterwards excluded from it.

During the process of distilling off the spirit from the fermented wash an hydrometer is employed to ascertain the strength of the liquid that passes over. As soon as this has fallen to a certain point, the operation is stopped, and the spent wash removed, and used as food for cattle. The spirits obtained by the first distillation are generally called *low wines*, and have a specific gravity of about ·975. By rectification or *doubling*, a crude milky spirit, abounding in oil, at first comes over, followed by clear spirit, which is received in a separate vessel. The process is continued until the alcoholic content of the distilled liquid has considerably diminished, when the remaining weak spirit that distils over, called *faints*, is caught separately, and mixed with the low wines preparatory to another distillation. The strongest spirit passes over first, and the condensed liquid gradually becomes weaker, until it ceases to contain alcohol. By receiving in separate vessels any given portion of the product, spirit of any required strength, within certain limits, may be obtained. The same object is more conveniently effected by surrounding the top of the capital of the still (which should be constructed of such a height as to obviate the contingency of the mash boiling over into the worm) with a water-bath, having a temperature corresponding to that of alcoholic vapour of the strength it is desired to obtain. Thus, if we keep the temperature of the water at about 198° Fahr., we shall obtain proof spirit; if at 192°, a spirit 20 o. p.; and so on for other strengths.

It is found from experience, and is easily accounted for by theory, that the lower the temperature at which the distillation is conducted, the stronger will be the product, and the less quantity of oil or other volatile matter will come over along with it. To promote this, it has been proposed to carry on the process *in vacuo*, but on the large scale this has never been adopted. The distillation of the wash is usually performed in a separate set of stills to those employed for the rectification of the low wines. For very strong and tasteless spirit, a third and even a fourth rectification is employed, conjointly with other methods, to abstract the water and to remove any foreign matter that vitiates its odour or flavour.* A portion of soap—generally 1 lb. to 100 gallons—is put into the still with the wash, to prevent excessive frothing. Butter is sometimes substituted for soap.

We have said that the processes of mashing, &c., in the distillery are similar to those adopted in brewing beer. We may add that, as richness in alcohol, and not flavour, is the object aimed at in the distiller's wash, not only is a large quantity of unmalted grain employed, but, what is self-evident, the process of boiling the wort with hops is omitted altogether.

* The above, which is known as the old method, is followed in some distilleries; whilst in the generality of works the process is accomplished by means of improved stills so constructed as to produce a strong spirit, sometimes as high as 65 o. p., at one distillation. In this country, except as in some establishments where the two are combined, the trades of the distiller and the rectifier are distinct. The distiller supplies the spirit to the rectifier, who not only frees it from certain bad tasting and bad smelling, as well as unwholesome principles, but imparts to it the specific flavour, by which it is transformed into the various alcoholic drinks, known as :—Whisky, British Brandy, Hollands, Gin, Rum, Cloves, Aniseed, Peppermint, &c., and the basis of all of which is the corn spirit of the British, and the potato and beet spirit, of the Continental distiller.

Again, when the raw grain exceeds the proportion of two parts to one of malted grain, the mashing should be made to extend over a longer time than if malt alone were used, and the water should not have a higher temperature than 145° Fahr. Unless this precaution is observed a large quantity of starch, derived from the unmalted grain, will escape saccharification, and being liberated in the liquid, will cause it to become "*set*," as it is termed, the yield of saccharine becoming, of course, diminished in proportion to the amount of this undecomposed starch. To avoid this, the distillers of France and Belgium defer adding the raw grain until the mashing of the malt has been effected. It has been found best not to use more than from three-fourths or half of the water intended for the first mashing at first, adding the remainder at short intervals towards the middle of the operation. After running off the first wort, the remaining grist is mashed in a similar manner. The second and third mashings, which may be made at a temperature of 180° Fahr., are used with the fresh grist for the first mashings of another brewing.

The successful result of the fermentation largely depends upon the quality of the yeast which is added to the wort. The most serviceable kind for this purpose is the best and freshest top yeast of the porter breweries, in quantity ranging from 1 to 1½ per cent. of the mash.

Only about three-fourths of the yeast are employed when the wort is first run into the fermenting vat, and the remainder after the second day. Some brewers use a small portion only of the required quantity on the first day, and add the remainder on the second, third, fourth, and even sixth day. Again, the yeast is never to be taken from the fermenting vat, but obtained from an independent source, a mixture of different kinds being preferred. The fermentation may occupy nine, ten, eleven, twelve, and even thirteen

days. During the first five days it is going on, the fermenting vessels are left open at the top, after which they are closed. As about one-fifth of the sugar in the wort escapes decomposition, owing to the anti-fermentative properties of the newly-formed alcohol, the distiller avoids operating upon too concentrated a wort. At the same time, a wort too diluted has its disadvantages, hence one of medium strength is preferred.

The rapid evolution of carbonic acid * from the surface of the fermenting liquid is a sign that fermentation is proceeding satisfactorily. When the disengagement of the gas flags, before the operation is properly completed, it is useless to attempt to restore the action. The best results are obtained when the wort is neither too concentrated nor too dilute. The aim of the distiller is to have the sp. gr. of the wash brought as low as possible. On the large scale the attenuation cannot often be carried below 1·000. Large fermenting vats are preferable to small ones, as they retain the heat better, and allow space for the frothing that always occurs during fermentation. In Germany the fermenting tuns are made of wood or stone; in the larger English distilleries they are of wood.

Other Sources of Spirituous Liquors. *From Potatoes.*—In France, Germany, and Denmark, large quantities of spirits of good quality are manufactured from potatoes, which contain about 21 per cent. of starch, the conversion of which into dextrose is effected either by:—Treating the boiled and broken up potatoes with malt, or with dilute sulphuric acid. The first process, which is that usually adopted is conducted as follows:—1. The potatoes, pre-

* The disengagement of gas and rise of temperature during fermentation is sometimes so great as to necessitate workmen being employed to beat down the large amount of froth which rises to the surface and would otherwise overflow the fermenting tub.

viously cleansed from adhering earth, but not peeled, are first boiled for an hour and then steamed; they are then cut into small pieces by a chopping-machine, during which operation they must be kept at a steam heat, the better to enable them to subsequently mix with hot water and so be made into a uniform mass. Sometimes the boiled potatoes are mashed by being passed between two hollow cylinders of cast-iron, the axles of which are so arranged and fitted into a framework as to admit of the cylinders being moved in an opposite direction. The ground malt, or the substance containing the diastase, being made into a thin paste with warm water, the potato mass is then added to it, the mixture well stirred to remove lumps, and the mashing proceeded with as with malt, the fermentation being set up with artificial yeast. The proportion of water varies from 3 to 4 parts to 1 of potatoes. The malt employed is sometimes rye-malt, sometimes barley-malt, but mostly a mixture of the two. The proportions of malt and potatoes vary in different distilleries from 2 or 3 to 10 parts of malt to 95 of potatoes. The average quantities, however, are 5 parts of malt and 95 of potatoes. The addition to the potatoes and malt of carrots and beet-root is said to yield a larger quantity of spirit and of better quality. 2. According to LEPLAY's method, the potatoes are first converted into a pulp, which is thrown into a large vessel containing water. The starch cells separate, some falling to the bottom of the vessel, others becoming mixed with the cellular tissue of the pulped potatoes. The brown coloured supernatant fluid is first syphoned off. This liquid serves as drink for cattle, or is used for the purpose of moistening dry fodder. Whilst this operation is in progress, the required quantity of dilute sulphuric acid is heated (generally by means of steam pipes) to the boiling-point in another vessel. To every 22 imperial gallons of potatoes from $3\frac{1}{4}$ lbs. to 4 lbs. 4 oz. of strong sulphuric acid, diluted

with from $5\frac{1}{4}$ pints to 7 pints of water, is usually taken.* The potato starch, which has been previously washed, is then gradually added in small quantities to the boiling diluted acid.

The boiling is continued until the whole of the starch, as well as the dextrin, is converted into glucose, the course of the progress of the conversion being ascertained by means of iodine water, whilst the insolubility of dextrin in alcohol affords a means of learning whether the conversion of this substance is complete, since a sample of the fluid, when shaken with alcohol, should give no milky appearance. After about four hours' boiling, the formation of sugar is completed. The fluid is then run into a vessel with double bottoms, one of which is perforated with small holes, and thus acts as a strainer in keeping back the cellular tissue, &c., after which the fluid is conveyed into another vessel, where it is neutralized by the addition of chalk. When the sulphate of lime has subsided the clear fluid is transferred to a third vessel. After the waste water of the sediment has been added, the mixed liquids are ready for fermentation.

Directly the wort wash has cooled, to every 220 lbs. $1\frac{3}{4}$ pints to $3\frac{1}{2}$ pints of beer yeast are added, and after about 60 to 70 hours, provided the fermentation has been favourable, as indicated by the regular appearance of scum on the surface at one side of the vat, and its equally regular disappearance down the other side, the wash is ready for distillation.

From *Artichokes.* A very pure and well-flavoured spirit, much resembling that from the grape, is obtained in some districts of France from the tubers of the Jerusalem artichoke (*Helianthus tuberosus*). Besides sugar, the tubers contain

* WANRICH uses the sulphuric acid in the proportion of 1 or 2 parts of acid to 99 of starch, and employs a steam heat at a little above 212° Fahr.

inulin, a substance easily convertible into sugar. The tubers are either rasped like beet-roots, or steamed or crushed like potatoes, treated with a small quantity of malt, and then fermented like potato-mash.

From *Beetroot* (DUBRUNFAUT'S method) 1,000 parts of beet-juice obtained either by pressure or maceration, are mixed with two parts of sulphuric acid, heated to 68° Fahr., and placed in a vat with some yeast. When a brisk fermentation sets in, a large cylinder, so constructed as to resemble a sieve of perforated sheet-iron, filled with beet (cut into slices $1\frac{1}{2}$ in. wide and $\frac{1}{6}$ of an inch thick, and previously acidified with sulphuric acid) is let down into the liquid. After the slices have been added, the temperature of the fermenting liquid is maintained at 68° to 75° Fahr. When the fermentation is complete, the sieve cylinder is withdrawn, and when the greater part of the liquid has drained off through the perforated bottom of the cylinder, the beet slices are submitted to distillation. For this purpose they are placed in iron dishes, perforated in the centre, so as to be attached to an iron rod, one above another, the iron rod being then, by means of a pulley, swung into a cylinder of the distilling apparatus, the cylinder being then hermetically sealed. The upper part of this cylinder being provided with an escape pipe connected with a rectifier and condenser, steam is passed in through a pipe at its lower part, by which means the alcohol becomes converted into vapour, and then passes into the rectifier.

Immediately after the beet slices have been removed from the fermenting-tub, a fresh cylinder-full is added to the liquid, and the fermentation can thus be carried on for the period of a month, by adding fresh slices as required.

During the fermentation, a larger volume of juice has passed from the beet slices, than that of the fermented liquid which these have absorbed. This excess, therefore,

which would overflow upon the immersion of a fresh cylinder of slices into the vat, is removed with the fermented slices into the distilling apparatus. The distillation is found to be carried out most efficiently when three stills are employed. At the commencement of the operation each still is filled with freshly fermented beet, and a corresponding quantity of juice. Steam is then introduced into the bottom of the first still, and communication made with the condenser. As soon as the distillate which passes over is found to be poorer in alcohol, communication with the condenser is shut off, and the vapour from the first still is carried into the second. When the contents of the first still have given up all their alcohol, the steam is shut off from it, and admitted directly into the second cylinder, which is put into communication with the third. In the meantime the first still is being emptied and filled with fresh slices, so that by the time the distillation in the second cylinder is finished, the third can be connected with the freshly filled first cylinder, and the operation made continuous.

The molasses from the beet-root, are also used for the production of a drinking spirit. Owing, however, to the large quantity of potash the molasses contain, it is first necessary to neutralize this by sulphuric acid, and if, after this has been done, sulphuric acid is again added in sufficient quantity to convert the cane-sugar of the molasses into glucose, fermentation may be easily set up by the ordinary method, and continued until the glucose is converted into alcohol, which is distilled by the usual processes: 230lbs. of molasses give on an average a yield of about 9 gallons of spirit. Spirit obtained from beet-root requires careful rectification, since it is largely contaminated with fusel oil.

From the residue left after distillation in the retorts, considerable quantities of potash are extracted.

Carrots.—This vegetable contains about 5 per cent. of

sugar, and is used by the foreign distillers as a source of alcohol. Many years ago Dr. Hunter and Mr. Hornby, both of York, were the first to manufacture spirits from carrots. They obtained 200 gallons (old measure) of proof spirit from 20 tons of carrots. At the time their experiments were made, they estimated the refuse carrots would realize £4 if sold as food for hogs. The carrot spirit was equal in flavour to the best corn spirit.

From Fruit (*Cherries*).—The agreeable spirit known as *Kirsch-wasser*, and principally manufactured in the Black Forest and Switzerland, is prepared from sound cherries, as follows:—The cherries being freed from their stalks, are first slightly crushed; generally about a fourth of this crushed fruit is then removed and again crushed, so as to break the stones, and bruise the contained kernels; but as these impart to the spirit the almond flavour that characterizes it, the amount of stones employed, and, therefore of fruit used for this purpose, varies with the degree of flavour required. The crushed fruit and stones are then returned to the remainder, and the whole is allowed to ferment, which it soon does very readily. As soon as the fermentation is over, the frothy mass is submitted to distillation by forcing steam through it, the distillate being collected as long as it is sufficiently rich in alcohol. The weaker spirit which passes over is collected separately, and added to the next quantity of pulp intended to be distilled.

From Milk (Rac).—A spirituous liquor is prepared by the Calmucs and Tartars by fermenting mare's milk, previously kept until sour, and then skimmed. By distillation it yields a spirit known as *Koumiss*. Twenty-one lbs. of fermented milk yield about three-quarters of a pint of *low wines*, and this by rectification gives fully five fluid oz. of strong alcohol.

During the fermentation of the mash obtained from grain

or potatoes, if the process be conducted at a high temperature, and the saccharine fluid be in a concentrated form, there are generated certain acrid, bad smelling, and highly unwholesome products, consisting of complex ethers and homologous alcohols, by far the most prominent ingredient in which, is amylic alcohol, having the formula $C_5H_{12}O$. This mixture of the above substances, which is known as *fusel oil** is invariably removed from the spirit by the distiller before he supplies it to the rectifier.

Various methods have at different times been suggested for ridding the spirit of this objectionable substance. Many of these refer to the use of oxidizing substances, such as

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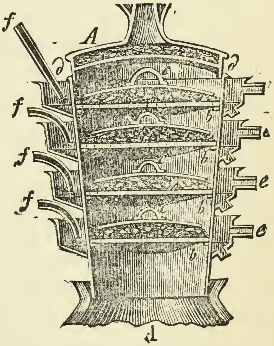
* Fusel Oil, which is also known as *Fousel Oil, Potato Oil, Oil of Potato Spirit, Grain Oil, Marc Brandy Oil*, is a nearly colourless, volatile liquid, with a rather high boiling point, a durable, penetrating, offensive smell, and an acrid, burning taste; when swallowed, it occasions nausea, giddiness, headache, &c.; in slightly larger quantities, vomiting, delirium, oppressive respiration, and lessened sensibility to pain; its vapour also produces these effects. In quantity, it is a narcotic poison. The greater intoxicating power of whisky, more especially that from raw grain, than other spirit, is due to the larger quantity of fusel oil which it contains. This appears to be well known to the lower class of whisky drinkers in these countries, and to the consumers of corn brandy in some of the northern parts of Europe. The last are said to frequently demand to be served with "a glass of good fusel." The fusel oil, obtained after the spirit (marc-brandy) has passed over during the distillation of the fermented residuum of expressed grapes, is a limpid, odorous, acrid, offensive liquid, which soon turns yellow in the air, is soluble in 1,000 parts of water, and in all proportions in rectified spirit. Six or seven drops will spoil a hogshead of brandy. According to M. Balard, this oil is a mixture of potato oil and œnanthic ether. The presence of fusel oil in spirit may be detected by its peculiar taste and smell. Even after considerable dilution with water the taste remains, whilst its smell develops itself in very marked manner if a small quantity is rubbed between the hands. Another test is afforded by a solution of nitrate of silver, which, if added to spirit and exposed to sunlight, shows a reddish colour if fusel oil be present in it.

manganate and permanganate of potash, chlorine, ferric chloride, hypochlorite of lime, and the cupric salts, a mixture of sulphuric acid and bichromate of potash and manganese, &c. By treating the spirits containing fusel oil with a mixture of sulphuric acid and dilute acetic acid, in addition to acetic ether, acetate of amyl is formed, with the result that a substance with an agreeable fruity flavour has been substituted for an especially malodorous and bad tasting one. Hydrochloric and nitric acids act somewhat similarly. The most effective agent, however, and the one now mostly adopted for the removal of fusel oil, is well-burnt charcoal, obtained either from wood, peat, or bones—preference being given by Stickel to the last. This method for the removal of the fusel oil is adapted for all spirits, except brandy obtained from wine. Two processes are in vogue in Germany for its application. The first consists in digesting the spirit with charcoal, and afterwards filtering it at the ordinary temperature of the air. Payen says the only tolerably efficient method is filtration of the spirit, diluted to about 50 per cent., through wood charcoal. Lowitz, after a series of experiments, found that five ounces of charcoal digested for two hours with 1 lb. of spirit, entirely removed from the spirit the smell due to fusel oil. In the second, the charcoal after being granulated, and freed from any dust, by passing it through a sieve, is placed in a copper cylinder, fitted at top and bottom with a perforated plate. This cylinder being connected with a distilling apparatus, between the condenser and rectifier, is so arranged that the alcoholic vapours pass through the charcoal. To every 22 gallons of spirit to be purified $5\frac{1}{4}$ lbs. to 9 lbs. of charcoal prepared as above are required. The charcoal can again be utilized by after exposure to a bright red heat.

Falkman's apparatus (shown on the other page), which is one of the best for the purpose, consists of a helm-shaped

vessel *A*, in which are arranged four perforated shelves, *b b b b*, upon each of these diaphragms a layer of charcoal is placed, and over these a cover *c*. A hollow cover fitted with a layer of charcoal, *d d*, fits over the top of the vessel. A cooling apparatus, consisting of cold water tubes, *f f f*, and hot-water tubes, *e e e e*, surrounds the vessel *A*, by which means the temperature of the layers of charcoal is regulated, since were a boiling temperature to be attained, the fusel oil absorbed by the charcoal would again be evolved and absorbed by the distillate.

Fig. 7.



There still remain in the spirit certain volatile oils, which vary in character with the substance which has been used as the source of the alcohol. Most of these oils possess a bad odour and a hot disagreeable taste, and cannot be eliminated by redistillation, because of the facility with which they pass into the distillate. For the removal of these the rectifier employs a mixture of caustic potash or soda and pearl ash; the former substance being known in the trade as "grey salts," and the latter as "white salts." According to Muspratt the proportion of salts employed is about 4 lbs. of grey salts, and 4 lbs. of white salts, to 700 gallons of "plain spirits" as received from the distiller. The above proportions vary with the amount of impurity which the rectifier, from his experience, infers to be present. The salts are dissolved in about two gallons of the spirit, and after the liquid has been allowed to deposit its sediment and then filtered, it is mixed with the crude spirit and submitted to distillation. When a common still is used,

the fire must be carefully watched, so as to avoid the risk of the spirit boiling over through the neck of the still, which would, of course, spoil the operation. Such risk is, however, impossible when the improved modern stills are employed.*

Filtration of the plain spirit through slaked lime before distillation, and its rectification from wood ashes, have also been recommended for the removal of the contaminating substances. For getting rid of the objectionable flavour sometimes met with in spirits obtained from wines made from ripe and sweet fruit, CADET DE VAUX recommends its distillation from milk. If one distillation does not succeed a second should be tried.

The quantity of spirit obtained from various substances, and even from pure sugar, depends upon the skill with which the several operations are conducted. By theory, pure sugar should yield 51 per cent. of alcohol; but in practice 11·925 galls. of proof spirit is the largest quantity which has yet been obtained from 112 lbs. of sugar. By the revenue authorities this weight of sugar is estimated to afford $11\frac{1}{2}$ galls. of proof spirit. The average product is, perhaps, about 1 gall. of spirit of this strength for every 10 lbs. of sugar. According to Harmstadt, 100 lbs. of starch yield 35 lbs. of alcohol, or 7·8 galls. of proof spirit; and 100 lbs. of the following grains produce the accompanying quantities by weight of spirit of sp. gr. ·9427, or containing 45 per cent. of pure alcohol:—wheat, 40 to 45 per cent.; rye, 36 to 42 per cent.; barley, 40 per cent.; oats, 36 per cent.; buckwheat, 40 per cent.; maize, 40 per cent.; the mean being 3·47 galls. of proof spirit. It is found that a bushel of good malt yields 2 galls. of proof

* Chemistry as applied to the Arts and Manufactures. Mackenzie: London, Dublin, and Edinburgh.

spirit, and that the largest qantity of proof spirit obtained from raw grain, mashed with $\frac{1}{5}$ or $\frac{1}{6}$ of malt, does not exceed 22 galls. per quarter.

The Commissioners, constituting the Board of Inland Revenue, as collectors of the Government duty on spirits, exercise, through their officers, a very rigid supervision over all the operations carried on in distilleries. The Act of Parliament, from which they derive their powers, was passed in 1825. It provides that no distiller can practice his trade without a license, which is to be renewed yearly. It lays down strict rules as to the number and capacity of the stills and receivers employed, and also the number of times he is allowed to charge his retorts. An excise officer is required to be present during every distillation, day or night. This official permits nothing to pass from one vessel to the other without his knowledge; in short, every detail of the process of the distillation is watched and controlled by him. By a late Act, it has been enacted that no spirit receiver shall be used in any distillery which is not made, placed, and fixed to the satisfaction of the Inland Revenue Commissioners, and which is not sufficiently deep to admit of the gauge being taken of the depth of fifteen inches in the centre; and every such receiver shall be so filled that at the time of gauging the same, for the purpose of charging the duty thereon, the depth of the spirit shall not be less than fifteen inches, under a penalty of £50. By the Sale of Food and Drugs Amendment Act of 1877, brandy, whisky, and rum must not be sold weaker than 25 u. p., and gin 35 u. p (42 & 43 Vic., c. 30. s. 6.)

The distiller is allowed to produce wort from any substance, and at any specific gravity, provided such gravity can be correctly ascertained by the saccharometer approved by the Board of Inland Revenue. He is not, however, allowed to mash and distil at the same time; hence, in a

distillery, the processes of brewing and distilling are carried on in separate parts of the building, and at different times.*

Spirituous liquors, like all other fluids at common temperatures, expand when they are heated, and diminish in volume when they are cooled. It is found that 1,000 galls. of proof spirit, measured at the temperature of 50° Fahr., will, if re-measured at 59°, be found to have increased in bulk to full 1,004¼ galls.; whilst 1,000 galls. of the same spirit, measured at 77° Fahr., will be only equal to 991¼ galls. at 59 Fahr. These changes are still more marked at higher strengths, and at extreme temperatures, and, from not being recognizable by the hydrometer, often lead to serious losses in trade, and to serious fluctuations in stock, which, to those unaware of the action of temperature, are perfectly unaccountable. A gallon of proof spirit only weighs 9⅕ lbs. at 60° Fahr. At a higher temperature it will weigh less, at a lower one more; but as this weight constitutes the standard gallon at the temperature the proof is calculated for, it is manifest that any variations from it must result in loss either to the buyer or seller. Hence the equity of buying and selling liquors by weight instead of by measure. The stock-keeper in every wholesale house should be aware of this fact, and on taking stock should as regularly enter the temperature of his liquors in his stock-book as he does the "dip" or wet inches. (*See* page 52.)

Arrack.—(*Syn.* ARAC, ARACK, RACK, PALM-SPIRIT.)—A spirituous liquor imported from the East Indies. The finer qualities are distilled from the fermented juice known as toddy, palm-wine of the cocoa-nut tree, Palmyra tree, and other palms; another variety is made in large quantities from malted rice. The rice is put into a vat and

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* As a rule the brewing takes place at the beginning of the week, the distilling at the end.

agitated with water until half of it has germinated; at this point the water is run off from the rice, which being removed to a warm room and dried at a temperature of 59° Fahr., its further germination is arrested. The malted rice is then subjected to precisely the same process as the malt or malted grain of the distiller—that is, after being made to undergo fermentation, it is put into a still and submitted to distillation the same as the wort obtained from grain. Other kinds of arrack are made from rice-beer, fermented with cocoa-nut or palm-juice, either with or without the addition of coarse sugar or jaggery. A French writer states that by fermenting, distilling, and rectifying the juice of the American maple, which has much the same taste as the juice from the cocoa-palm, he made an arrack not at all inferior to that manufactured in the East Indies.

Arrack is colourless or nearly so, but, like other spirit, when long kept in wood, gradually acquires a slight tinge, similar to that of old Hollands. The best kinds, when of sufficient age, are pleasant flavoured, and are probably as wholesome as the other spirits of commerce; but common arrack has a strong and somewhat nauseous flavour and odour, depending on the presence of volatile oil derived from the rice, and corresponding to that of corn-spirit. The inferior qualities are hence more heating and apt to disagree with the stomach than the other commercial spirits. In this country it is chiefly used to make punch. When sliced pine-apples are put into good arrack, and the spirit kept for some time, it mellows down and acquires a most delicious flavour, and is thought by many to be then unrivalled for making "nectarial punch" or "rack-punch."

The arrack from Goa and Colombo is most esteemed. In Goa the toddy or juice from which the arrack is distilled is chiefly obtained by incision. A two-quart pot is fixed in the evening, by a bandage, to a part of the palm from

which a shoot has been cut, and in the morning it is found filled with the juice and removed. Other kinds are regarded as inferior. The common pariah arrack is generally narcotic, very intoxicating, and unwholesome; being commonly prepared from coarse jaggery, spoilt toddy, refuse rice, &c., and rendered more intoxicating by the addition of hemp-leaves, poppy-heads, juice of stramonium, and other deleterious substances.

A fictitious arrack, known as "Vauxhall nectar or British arrack," which was formerly in great demand, was made as follows:—Good old uncoloured Jamaica rum, clean flavoured, rectified spirit (54 to 56 o. p.), and water, of each 1 quart; flowers of benzoin, 1 drm.; sliced pine-apple, $\frac{1}{4}$ oz. (or essence of pine-apple, $\frac{1}{2}$ teaspoonful); digest, with occasional agitation, for a fortnight; then add of skimmed milk 1 wine-glassful; agitate well for 15 minutes, and in a few days decant the clear portion.

The light brown cotton-like substance from the outside of the base of the fronds belonging to the Palmyra palm is employed by the Cyngalese doctors as a styptic for stopping the hæmorrhage of superficial wounds.

Brandy.—(*Syn.* Eau-de-vie. Cognac.)—A well-known spirituous liquor obtained by the distillation of the wine of grapes. The name is also often, though improperly, given to the spirit distilled from other liquors, and particularly from the fermented juice of fruits; but in this case usually with some qualifying epithet.

Old wines yield a better brandy than new, and sweet wines than spoilt ones; whilst white wines give a superior spirit to that obtained from the red varieties. Of course, the better the wine the better the brandy. It is also a known fact that wines grown in different localities very frequently impart the flavour of the soil to the brandy manufactured from them; thus, brandy obtained from the wine peculiar to

St. Pierre, in Vivarais, has a violet aroma, whilst that made from the Moselle wines has a slaty taste, and that from the wines of Holstein, a flavour resembling that of oil of amber.

When first distilled, brandy, like other spirituous liquors, is colourless, when it is known as WHITE BRANDY, and continues so if kept in glass or stoneware; but if stored in new oak casks, as is usually the case, it gradually acquires a yellowish tint from the wood, and is then termed PALE BRANDY. The deep colour which this spirit frequently possesses when it reaches the consumer, is imparted to it by the addition of a little burnt sugar or caramel. Catechu, or terra japonica, in powder or suspension, is also sometimes added to give a roughness to the spirit. The original intention was merely to imitate the appearance acquired by brandy from great age, when kept in wood; but in process of time the practice of making these additions was carried to excess. The natural colour which the spirit receives from the cask, however long it may be kept in it, never exceeds a light amber tint, like that of pale Jamaica rum. Other characteristics of genuine French brandy are that it is neither rough nor fiery to the palate, and does not taste of the cask. New casks impart an astringent, disagreeable taste to the brandy.

The most esteemed brandies are those of Cognac, Cette, Bordeaux, Rochelle, Charente, L'Isle de Ré, Angoulême, Saumur, Orleans, Blois, Tours, Angers, and Nantes. At Andaye (Basses Pyrénées), a sweet brandy, flavoured with aniseed, is also very popular. The wines from the South of France are about double as rich in alcohol as those from the North. The brandies obtained from Portugal, Spain, and Italy are very inferior.

The constituents of pure brandy are alcohol and water, together with small quanties of a volatile oil, acetic acid, acetic ether, œnanthic ether, colouring matter, and tannin. It

is from the presence of the two ethers that the spirit derives its characteristic smell and flavour. The amount of absolute alcohol in brandy varies from 45 to 55 per cent. When first imported it is generally one or two over-proof, but its strength decreases by age, and by the time it is taken from the bonded store for sale, it is seldom stronger than 3 or 4 under-proof. Pure brandies of the best quality, even when new, seldom exceed proof, and are generally a little below it. The reason of this is that they are but slightly rectified, as re-distillation tends to injure the ethereal oils, upon which the flavour of the brandy depends.

The quality and flavour of the brandy imported from France vary, and often considerably, from that which is drunk at the best tables on the Continent; this principally arises from its being prepared, or, as it is technically termed, "made up," for the London market; which means lowering it by the addition of plain spirit, colouring, &c. In large quantities, and from bond, the strength, of course, depends much upon the age and quality of the spirit; a fine old brandy being, perhaps, 15 or 17 u. p., while one of the last year's vintage, of a commoner quality, may be as strong as 2 u. p., or even 1 u. p. These matters are familiar to every experienced brandy dealer.

In France there are several varieties of brandy, which are known by the names descriptive of their qualities, sources, and strength:—

"Eau-de-vie supérieure" is obtained from pale white wines by skilful distillation, and is remarkable for its rich and delicate flavour. It forms the finest variety of Cognac brandy, both "white" and "pale," of the English drinker, being seldom artificially coloured. Its deepest tint, though long kept in wood, never exceeds a pale amber; and hence, even when thus coloured, it is frequently called "white brandy" by the uninitiated.

"Eau-de-vie ordinaire," or common brandy, is distilled from inferior or spoilt white or red wines; average sp. gr. about 0·9476 (from 22 to 27 u. p.). It forms the "ordinary brandy" of the taverns and hotels; and, after being "made up" with plain spirit to 1 or 2 u. p., constitutes a very large portion of that which is exported.

Of each of the above varieties there are numerous degrees of qualities, which are further increased in number by their admixture, and by the addition to them of plain spirit.

"Eau-de-vie de marc." From the lees of sour, damaged and inferior red wines, the marc or cake of grapes, &c., distilled by a quick fire, to drive over as much essential oil and flavouring matter as possible. Coarse flavoured and inferior. Used chiefly to mix with other brandy, or to flavour plain spirit. (*See* FUSEL OIL, p. 155.)

"Eau-de-vie seconde." The weak spirit that passes over, after the receiver has been changed. Very weak and inferior.

"Eau-de-vie à preuve d'Hollande." Sp. gr. ·941 to ·942 (18 to 20 u. p.). The common strength at which brandy is retailed in France, and that at which it stands the "proof" or "bead."

"Eau-de-vie à preuve d'huile." Sp. gr. ·9185 (about 23° Baumé, or $1\frac{1}{4}$ o. p.); pure olive oil just sinks in it. It is the strongest brandy kept for retail sale in France.

"Eau-de-vie forte." From common brandy distilled at a low temperature. It answers to our spirit of wine. Sp. gr. ·839 (38° Baumé, or 55° o. p.).

"Esprit de vin" is brandy or spirit, carefully rectified to ·861 (28° Baumé, or 42 o. p., and upwards).

The method of determining the strength of brandy is explained under ALCOHOLOMETRY. Of the large quantity of

this liquor consumed in England, a small fraction only escapes adulteration. Pure French brandy is indeed an article unattainable by the small consumer. A great part of the brandy of our shops and taverns is not only systematically lowered a little by the wholesale dealer, but it undergoes the same process, and to a much greater extent, at the hands of the retailer. The only method to obtain perfectly pure brandy is either to take it direct from the bond store, or to buy it of some well-known respectable house, and to pay a price that offers no inducement to dishonesty. When this cannot be done, British brandy had better be purchased, by which money will be saved, and a more wholesome article obtained.

French brandy, as already noticed, is commonly lowered with water, and as a consequence the spirit suffers so greatly in flavour, and its deficiency in alcohol becomes so apparent, that the unscrupulous vendor recognizes the necessity of either abandoning the practice, or of resorting to devices of a less harmful character. The latter alternative is commonly adopted. An excess of burnt sugar is introduced into the spirit, followed by sundry portions of cayenne pepper, grains of paradise, horse-radish, acetic ether, &c., to give it a pungency and fictitious strength that finds favour with the petty consumer. This fraud may be detected by gently evaporating a little of the suspected liquor in a spoon or glass capsule, when the acrid matter, colouring, and sugar will be left behind, and may be readily detected by their flavour, sweetness, burning effect on the tongue, &c. A little pure brandy evaporated in a similar manner (on a watchglass, for instance) leaves only a trifling discoloration on the surface of the glass. Genuine French brandy always reddens blue litmus paper, from containing a little acetic acid ; the old coloured varieties are also blackened by a solution of a persalt of iron. Another test for caramel or burnt sugar is to shake a small quantity of the brandy with

one-sixth of its volume of white of egg, and the precipitate formed being allowed to deposit, or being removed by filtration; the clear liquid ought to be colourless. Should caramel be present, however, it will retain its colour. Sometimes brandy is contaminated with a small quantity of lead or copper derived from the apparatus or utensils with which it has been prepared or measured. Sugar of lead has also sometimes been used by the ignorant dealer to clarify it. The presence of these highly deleterious substances may be detected in the following manner:—

1. Copper:—*a.* A small piece of clean polished iron or steel immersed in the suspected liquid for a short time, agitation being used, becomes coated with a film of metallic copper, when that metal is present. To facilitate the deposition of the metal, the sample under examination may be slightly acidulated with a few drops of pure acetic acid. Minute traces of copper may sometimes be detected on the surface of the iron by means of a lens, which would be passed over unnoticed by the naked eye.

b. (Böttger.) A little of the brandy is to be agitated with a few drops of pure olive oil. The latter will acquire a green colour if copper be present.

2. Lead.—*a.* Sulphuretted hydrogen and sulphide of ammonium produce a black precipitate or discoloration in brandy containing lead.—*b.* A solution of sulphate of soda or water acidulated with sulphuric acid produces a heavy white precipitate, which turns black when moistened with sulphide of ammonium.

3. Methylated Spirit, sometimes used as a sophisticant, may be detected by rubbing a little of the suspected brandy on the hands, and then drawing a long breath with the hands over the mouth. The peculiar odour of the methylated spirit, if present, then becomes evident. This is a test, however, requiring practice and experience.

For the determination of the alcoholic strength, *see* ALCOHOLOMETRY, p. 16.

The brandy may be roughly tested for fusel oil by burning a little of it in a dish, and depressing over the flame a saucer or other cold piece of porcelain. If a black stain is left, some of the lower alcohols are very probably present, and should be looked for by distilling half a pint of the spirit, and examining the later or heavier products. The vinic alcohol being the most volatile comes over first, the heavier fusel oil remaining until the later stages. *See* also FUSEL OIL, p. 155.

In the "trade," the addition of water, or "liquor," as it is called, to spirit, is technically called "reducing;" whilst absolute adulteration is known under the questionable name of "improving."

A liqueur was used, and may probably now be sold in London, under the name of "brandy improver," or "brandy essence." It was composed of a thin sugar syrup, flavoured with acetic ether and essence of cayenne, and coloured with burnt sugar, and was employed to heighten and simulate the true Cognac flavour, and to restore lost alcoholic strength.

Brandy, British.—(*Syn.* MALT BRANDY.)—For a long time this liquor was distilled from spoiled wine and the dregs of wine, both British and foreign, mixed with beer-bottoms, spoiled raisins, and similar substances. At the present day, spirit made from malt, potato, beet-root, and carrot, is employed. Malt spirit is the best adapted for the manufacture of British brandy.

We annex formulæ:—

1. To 12 galls. of malt spirit at proof, add, of water, 5 galls.; crude red tartar or winestone, previously dissolved in 1 gall. of boiling water, ¾ lb.; acetic ether, 6 fl. oz.; French wine-vinegar, 2 quarts; French plums (bruised), 5 lbs.;

sherry bottoms, ½ gall.; mix these ingredients in a sherry or French brandy-cask, and let them stand for about a month, frequently "rummaging up" the liquid with a stick; next draw over 15 galls. of the mixture from a still furnished with an agitator. Put the distilled spirit into a clean, fresh-emptied Cognac-brandy cask, and add of tincture of catechu, 1 pint; oak shavings, 1 lb.; and spirit colouring, ½ pint; agitate occasionally for a few days, and then let it repose for a week, when it will be fit for use. This produces 15 galls. of brandy, 17 u. p. Age greatly improves it.

2. Malt spirit, 99 galls.; red tartar (dissolved in water), 7 lbs.; acetic ether, ½ gall.; wine-vinegar, 5 galls.; bruised raisins or French plums, 14 lbs.; bitter-almond cake (bruised and steeped for twenty-four hours in twice its weight of water, which must be used with it), ¼ lb.; water, q. s.; macerate as before, and draw over, with a quick fire, 120 galls. To the distilled spirit add a few lbs. of oak shavings; 2 lbs. of powdered catechu made into a paste with hot water, and spirit-colouring, q. s.; and finish as in the last. Produces 120 galls. of spirit, fully 17 u. p. Equal in quality to the last.

3. Clean spirit (17 u. p.), 100 galls.; nitrous ether, 2 quarts; ground cassia buds, 4 oz.; bitter-almond meal, 5 oz.; sliced orris-root, 6 oz.; cloves, in powder, 1 oz.; capsicum, 1½ oz.; good vinegar, 3 galls.; brandy colouring, 3 pints; powdered catechu, 2 lbs.; full-flavoured Jamaica rum, 2 galls. Mix in an empty Cognac piece, and macerate for a fortnight, with occasional stirring. Produces 106 galls., at 21 or 22 u. p.

4. Malt spirit (17 u. p.), 100 galls.; catechu, 2 lbs.; tincture of vanilla, ½ pint; burnt sugar colouring, 1 quart; good rum, 3 galls.; acetic or nitrous ether, 2 quarts. Mix as the last.

5. Clean spirit (17 u. p.), 89 galls.; highly flavoured

Cognac, 10 galls.; oil of cassia, 2 drms.; oil of bitter almonds, 3 drs.; catechu, in powder, 1 lb.; cream of tartar, previously dissolved in water, $1\frac{1}{4}$ lbs.; Beaufoy's concentrated acetic acid, $\frac{1}{2}$ gall.; sugar colouring, 2 to 3 pints; good rum, 1 gall.

N.B.—To those of the above mixtures which are submitted to distillation, the French brandy, colouring substance, and catechu, must be added after, not before, distillation.

Brandy, Pale.—This article has been already referred to. That of the gin-shops and publicans is generally a spurious article, made by mixing together about equal parts of good brown French brandy, clean spirit of wine, and soft water, and allowing the whole to stand until the next day to fine down.

Brandy, Patent.—This is merely very clean malt-spirit mixed with about $\frac{1}{7}$th or less of its bulk of strongly flavoured Cognac, and a little colouring.

Brandy, Cider.—From cider and perry; also from the marc of apples and pears fermented. It is very largely manufactured in the United States and Canada.

Brandy, Dantzic.—From rye, ground with the root of *Calamus aromaticus*. It has a mixed flavour of orris and cinnamon.

Brandy, Guernsey.—Beet-root spirit flavoured.

Shrub, Brandy.—1. Take of brandy, 1 gall.; orange and lemon juice, of each 1 pint; peel of 2 oranges; do. of 1 lemon; digest for twenty-four hours, strain, and add, of white sugar, 4 lbs., dissolved in water, 5 pints; in a fortnight decant the clear liquid for use.

2. As Rum Shrub, but using brandy.

In concluding the article on Brandy, we may remark that as the quality and strength of the ingredients frequently vary, and success depends greatly on skill in manipulation, much must be left to the experience, judgment, and discre-

tion of the operator. In all cases he must recollect that a certain degree of age is absolutely necessary to give a high character to any spirit. Indeed, to age in the one case, and its absence in the other, may be referred the reasons why French brandy and British brandy, apart from mere shades of flavour, so materially differ.

The production of a flavoured British spirit closely resembling French brandy, but *sold* as British, is a subject well worthy the attention of the ingenious chemist, rectifier, and cellarman.

Gin.—(*Syn.* GENEVA.)—Corn spirit flavoured with either oil of juniper or oil of turpentine, or juniper berries and various other substances.

Gin was originally and, for some time, wholly imported from Holland, and was a rich, soft spirit, flavoured chiefly with juniper berries; on which account it had obtained the name of "GENEVA," from "GENIÈVRE," the French for juniper. After a time the distillation of an imitation Geneva sprang up in this country, when the foreign spirit came to be called "HOLLANDS," or "HOLLANDS GENEVA," to distinguish it from the spirit of home manufacture. The English monosyllable "GIN" is a corruption of Geneva, the primary syllable of which, as in numerous other instances, was seized on by the vulgar, and adopted as a short and convenient substitute for the whole word.

The liquor at present known by the name of "gin" in this country, is a very different article to that imported from Holland. The thousand-and-one receipts for this article, which have from time to time been printed in books, produce a flavoured spirit bearing no resemblance to the best samples of English gin; and, if possible, the products are even more unlike genuine Hollands. Any person may easily satisfy himself of the truth of this assertion by actual experiment on the small scale. The cause of this

incongruity has arisen chiefly from the writers not being practically acquainted with the subject, and from the disinclination of well-informed practical men to divulge, gratuitously, what they conceive to be valuable secrets. In practice, it is found that the true flavour of foreign Geneva cannot be imparted to spirit by juniper alone, and that the English gin of the present day depends for its flavour on no such a substance. It is proper to remark that every distiller has his own receipt for this notorious beverage. Hence it is that the gins of no two distillers are of precisely the same flavour; and this difference is still more marked when the distillers reside in parts of the country remote from each other. The gins of different rectifiers have each a characteristic flavour. These variations in flavour generally depend on the use of more or less flavouring matter, or of a spirit more or less clean or free from taint; and, less frequently, on the addition of a small quantity of some peculiar aromatic, which exercises a modifying influence on the chief flavouring ingredient. In many cases the flavour has originated from accident, but the consumers having become accustomed to it, the distiller finds it unwise or commercially impossible to alter it.

In the preparation of gin, both sweetened and unsweetened, and indeed of spirituous liquors generally, the greatest possible care must be taken to avoid an excess of flavouring. The best samples are those which consist of very pure spirit, slightly flavoured.

We append formulæ:—

1. Clean corn spirit, at proof, 80 galls.; newly rectified oil of turpentine, $1\frac{1}{4}$ pint; mix well by violent agitation, add culinary salt, 14 lbs., dissolved in water, 40 galls.; again well agitate, and distil over 100 galls., or until the faints begin to rise. Produces 100 galls. of gin 22 u. p.,

besides 2 galls. contained in the faints. If 100 galls. at 17 u. p. are required, 85 galls. of proof spirit, or its equivalent at any other strength, must be employed.

2. Proof spirit (as above), 8 galls.; oil of turpentine, 1 fl. oz.; salt, 1½ lb., dissolved in water, 4 galls.; draw over 10 galls., as before. 22 u. p.

3. Clean corn spirit, 80 galls.; oil of turpentine, 1 pint; pure oil of juniper, 3 fl. oz.; salt, 21 lbs.; water, 35 galls.; draw over 100 galls., as before. 22 u. p.

4. To the last, before distillation, add, of oil of caraway, ½ fl. oz.; oil of sweet fennel, ¼ fl. oz.; ground cardamoms, 8 oz.

5. To No. 3 add of essential oil of almonds, 1 dr.; essence of lemon, 4 drs.

6. To No. 1, before distillation, add of creasote, 3 fl. drs.

7. To No. 3 add of creasote, 2 drs.

8. Proof spirit, 80 galls.; oil of turpentine, ¾ pint; oil of juniper, ¼ pint; creasote, 2 drs.; oranges and lemons, sliced, of each 9 in number; macerate for a week, and distil 100 galls. 22 u. p.

9. To No. 1 add of oil of juniper, ½ pint.

The oil of turpentine for this purpose should be of the best quality, and not that vended for painting, which always contains resin, and often fixed oil. Juniper berries, almond-cake, and the aromatic seeds, may be used instead of the essential oils; but the latter are the more convenient. Juniper berries may be employed in the proportion of 100 lbs. to 1,000 gallons of spirit; coriander seeds the same; almond-cake 5 lbs. to the 1,000 gallons; orris-root 2 lbs.; angelica-root 3½ lbs. Turpentine conveys a plain gin flavour, juniper berries or oil gives a Hollands flavour, creasote imparts a certain degree of smokiness, or whisky flavour, lemon and the other aromatics, a creaminess, fulness, and richness.

The flavour imparted by cardamoms, when used judiciously, is peculiarly agreeable and appropriate. So also is that from caraways and cassia in extremely small proportions. The only danger in the employment of all these articles is using too much of them. When this misfortune happens, the remedy is to add sufficient plain spirit to reduce the flavour to the proper standard. The creaminess and smoothness so much admired in foreign Geneva results chiefly from age. The English rectifier endeavours to imitate this by the addition of a little sugar. A rich mellowness, that combines well with gins having a Hollands flavour, is given by a very small quantity of garlic, Canadian balsam, or Strasburg turpentine. The peculiar piquancy, or the property of biting the palate, regarded as a proof of strength and quality by the ignorant gin-drinker, is imparted to the liquid by the addition of a little caustic potassa, a very objectionable adulteration. Sliced horse-radish gives piquancy as well as mellowness. Grains of paradise, cayenne pepper, and sulphate of zinc, are also added by fraudulent dealers.

Although gin is always prepared on the large scale by distillation, it may also be made by the simple solution or digestion of the flavouring ingredients in the spirit; but it is, of course, better for distillation. If prepared by the former method, no salt must be employed. The gin produced by the above formulæ is that denominated in the trade UNSWEETENED GIN, GROG GIN, &c.; but the gin usually sold in the metropolis is a sweetened spirit, and hence is technically distinguished by the terms SWEETENED, or MADE UP. The generality of London gin-drinkers prefer the latter article, even when weaker and inferior, which it usually is, as the addition of sugar permits adulteration and watering to an enormous extent with absolute impunity. Sweetened spirit cannot be easily tested for its

strength, and is taken by the Excise at the strength which it is declared to possess by the dealer. To ascertain whether gin is sweetened or not, a little may be evaporated in a spoon, over a hot coal or a candle, when, if it is pure, it will leave the spoon scarcely soiled; but if, on the contrary, it has been sweetened, a small quantity of syrupy liquid, or sugar, will be obtained, the sweetness of which may be easily recognized by tasting it. (*See* ALCOHOLOMETRY.)

The whole of the casks and utensils employed for gin should be perfectly clean, and so treated as to impart no colour to their contents, since if this spirit acquires the palest coloured tint, its value is lessened, whilst if much coloured it is rendered unsaleable. When gin has once become much coloured, the only remedy is to re-distil it; when it is only slightly coloured, acetic acid of the strength of the British Pharmacopœia in the proportion of a spoonful or two to a gallon, or a few drops to a decanterful, will usually decolour it, either at once or as soon as it is mixed with water to make grog.

CORDIAL GIN is gin sweetened with sugar, and slightly aromatized.

Prep. Good gin (22 u. p.), 90 galls.; oil of almonds, 1 drm.; oils of cassia, nutmeg, and lemon, of each 2 drms.; oils of juniper, caraway, and coriander, of each 3 drms.; essences of orris root and cardamoms, of each 5 fl. oz.; orange-flower water, 3 pints; lump sugar, 56 to 60 lbs., dissolved in water, 4 galls. The essences are dissolved in 2 quarts of spirit of wine, and added gradually to the gin until the requisite flavour is produced, when the sugar (dissolved) is mixed in, along with a sufficient quantity of soft water (holding 4 oz. of alum in solution) to make up 100 galls. When the whole is perfectly mixed, 2 oz. of salt of tartar, dissolved in 2 or 3 quarts of hot water, are added, and the liquor is again well

rummaged up; after which the cask is bunged up, and allowed to repose. In a week, or less, it will have become brilliant, and may be either "racked," or drawn from the same cask. The product is 100 galls., about 30 u. p.

Sweetened Gin is made from unsweetened gin (22 u. p.), 95 galls.; lump sugar, 40 to 45 lbs., dissolved in clear water, 3 galls.; mix well, and fine it down as above. Produces 100 galls., at 26 u. p. This, as well as the last, is usually "permitted" at 22 or 24 u. p., which is also done when the gin has been further lowered with water so as to be even 30 or 35 u. p.

Hollands. GENEVA, SCHIEDAM, HOLLANDS GIN, DUTCH GIN. 1. The materials employed in the distilleries of Schiedam, in the preparation of this excellent spirit, are 2 parts of the best unmalted rye and 1 part of malted bigg, reduced to the state of coarse meal by grinding. About a barrel (36 galls.) of water, at a temperature of from 162° to 168° Fahr., is put into the mash-tun for every $1\frac{1}{2}$ cwt. of meal, after which the malt is introduced and stirred, and lastly, the rye is added. Powerful agitation is next given to the magma till it becomes quite uniform, when the mash-tun is covered over with canvas, and left in this state for two hours. Agitation is then again had recourse to, and the transparent spent wash of a preceding mashing is added, followed by as much cold water as will reduce the temperature of the whole to about 85° Fahr. The gravity of the wort at this point varies from 33 to 38 lbs. A quantity of the best pressed Flanders yeast, equal to 1 lb. for every 100 galls. of the mashed materials, is next stirred in, and the whole is fermented in the mash-tun for about three days, or until the attenuation is from 7 to 4 lbs. (sp. gr. 1·007 to 1·004). During this time the yeast is occasionally skimmed off the fermenting wort. The wash, with the grains, is then transferred to the still, and converted into low wines. To

every 100 galls. of this liquid, 2 lbs. of juniper berries (three to five years old), and about 1 lb. of salt, are added, and the whole is put into the low-wine still, and the fine spirit drawn off by a gentle heat, one receiver only being employed. The product per quarter varies from 18 to 21 galls. of spirit, 2 to 3 o. p.

2. (BEST HOLLANDS.) Hollands rectified to the strength of 24° Baumé (sp. gr. ·9125, or about 6 o. p.).

3. DR. THOMPSON gives the following formula for preparing Gin, Geneva or Hollands. He states it is one used by the Dutch manufacturers:—112 lbs. of barley malt, and 228 lbs. of rye meal are mashed with 460 galls. of water, at 162° Fahr. After infusing a sufficient time, cold water is added until the gravity of the wort is reduced to 45 lbs. per barrel. The whole is let into a fermenting back at 80° Fahr., half a gallon of yeast is added, the temperature rises to 90°, and the fermentation is over in forty-eight hours. The wash is attenuated until the specific gravity is about 12 or 15 lbs. per barrel. Both the wash and grains are then put into the still; the low wines are distilled off; these are redistilled, and the product is rectified. A few juniper berries and some hops are used to communicate a peculiar flavour to the spirit.

4. (ENGLISH-MADE.)—*a.* From juniper berries (at least a year old, and crushed in the hands), 3 lbs.; rectified spirit, 1½ gall. (or proof spirit, 2½ galls.); digest, with agitation, for a week, and then express the liquid; after twenty-four hours' repose, decant the clear portion, add it to good corn spirit, at 2 or 3 per cent. over proof, 90 or 100 galls.; and mix them well together.

b. From juniper berries, 2½ lbs.; sweet fennel seed, 5 oz.; caraway seeds, 3½ oz.; proof spirit, 2 galls.; corn spirit, 90 or 100 galls.

c. As the last, with the addition of Strasburg turpentine or Canadian balsam, 1 lb.

d. To either of the last two or three add a very small quantity of ground cardamoms or horse-radish. Some compounders also add four or five cloves of garlic, or about 15 grains of assafœtida, with 1 grain of ambergris rubbed to a powder with a little white sand or lump sugar. Good plain gin may be advantageously employed in lieu of the corn spirit ordered above, when expense is no object.

The last four forms produce a very pleasant spirit, if it is kept for some time to mellow. Age is one of the principal causes of the creaminess of foreign gin, which usually lies in bond for some time before being consumed. The product is, however, much superior if the ingredients are rectified along with 20 galls. of water, and about 14 lbs. of salt, by a gentle heat.

It will be seen from the previous remarks that the superior flavour of Hollands spirit depends more on the peculiar mode of its manufacture than on the quantity of juniper berries employed. 2 lbs. of the berries, when fresh, are about equivalent to 1 oz. of the essential oil; and when old, to less than ½ oz. of oil, an insufficient quantity to flavour 100 gallons of spirit. Those Dutch distillers, who are most noted for this spirit, add a little pure Strasburg turpentine and a handful or two of hops, as before stated, to the spirit, along with the juniper berries, before rectification. The former substance has a pale yellowish-brown colour, and a very fragrant and agreeable smell, and tends materially to impart that fine aroma for which the best Geneva is distinguished. At Rotterdam sweet fennel seed is commonly added as a flavouring; and at Weesoppe, Strasburg turpentine and fennel seeds, or the essential oil of fennel, are frequently substituted for a large portion of the juniper berries.

Schiedam Hollands is considered the best; the next in quality is that of Rotterdam; after these comes that of Weesoppe.

Rum.—An ardent spirit obtained by distillation from the fermented skimmings of the sugar-boilers (syrup scum), the drainings of the sugar-pots and hogsheads (molasses), the washings of the boilers and other vessels, together with sufficient recent cane-juice or wort (prepared by mashing the crushed cane), to impart the necessary flavour. The sweet liquid before fermentation commonly contains from 12 to 16 per cent. of saccharine, and every ten gallons yield from one to two gallons of rum. Molasses alone yield the best rum.

1. The following is one of the processes followed in the Windward Isles for the preparation of rum. The ingredients, consisting of skimmings from the boiling juice of the sugar-cane, one-third, dunder* one-third, and water one-third, are run into fermenting cisterns and well mixed. In the course of about twenty-four hours, fermentation is set up in the mixture, when molasses, in the proportion of 6 gallons to every 100 gallons of the fermenting liquid, are added, by two instalments, the first 3 gallons at once, and the remaining 3 gallons a day or two afterwards, when the liquid is in a state of active fermentation. At this part of the operation the temperature, by the addition, according to circumstances, of cold or hot water, can be so regulated as to be at 90° or 94° Fahr. When the fermentation has ceased and the liquid has fined, it is run into the still and drawn over until it ceases to be inflammable, the low wines so obtained undergoing a second distillation.

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* Dunder (derived from the Spanish word *redunder*, corresponding with the Latin *redundans*) is the lees or feculence of previous distillations. A much larger quantity of spirit is said to be produced where dunder is employed than would be the case were the wort left to spontaneous fermentation. It is very rapid in action, and boiling water does not, as in the case of other ferments, destroy its power.

2. The following is a Jamaica formula:—

Dunder	50	gallons.
Molasses	6	,,
Sugar skimmings	36	,,
Water	8	,,
	100	

1,200 gallons of this mixture, when distilled, should yield 300 gallons of low wines. This process differs from the preceding one in directing the molasses to be added all at once, and not in two batches. A minute quantity of alkaline salt is sometimes added to the contents of the still.

In France large quantities of rum are manufactured from beet-root molasses, and LAUGIER'S still is largely employed for the purpose. In the West Indies and many other localities, where the spirit is made, a still designed by PONTIFEX is in very general use. It seems to be established that if very deep fermenting vats and stills are used, an inferior flavoured product is the result.

The average strength of rum, as imported into this country, is about 20 o. p. Like all other spirits, it is colourless when it issues from the still, but owing to the taste of the consumer the distiller is compelled to colour it before it leaves his premises.

Rum is imported from the East and West Indies, France, and America. The best comes from Jamaica, and is hence distinguished by that name. Leeward Island rum is less esteemed. The consumption of rum has long been declining in England; its place being chiefly supplied by gin. Rum owes its flavour to a volatile oil and butyric ether, a fact of which the chemist has availed himself in the manufacture of a butyric compound, known as "essence of rum," which is had recourse to by the spirit dealer to manufacture a factitious or English rum from malt or molasses spirit. In Jamaica it is usual to put sliced pine-apples into the pun-

cheons containing the finer qualities of rum, which is then termed pine-apple rum, and which imparts to new rum the qualities of the old spirit. Larousse states that cloves, tar, leather-cuttings, and caramel are used for the same purpose.

Rum Shrub.—1. As Brandy Shrub, but substituting rum for brandy.

2. Take of rum at proof, 34 galls.; essential oils of orange and lemon, of each 2 oz. dissolved in rectified spirit, 1 quart; good lump sugar, 300 lbs., dissolved in water, 20 galls. Mix well by rummaging, and gradually and cautiously add of Seville orange-juice, or of a solution of tartaric acid in water, q. s., to produce a pleasant but scarcely perceptible acidity. Next rummage well for 15 minutes, then add sufficient water to make the whole measure exactly 100 galls. Again rummage well for at least half an hour; lastly, bung the cask down loosely, and allow it to repose for some days. In a fortnight, or less, it will usually be sufficiently brilliant to be racked. The product is 190 galls., at 66 u. p.

Rum shrub is the kind in greatest demand, and that having a slight preponderance of the orange flavour is the most esteemed. If wholly flavoured with lemon it is apt to acquire a kind of vapid or musty flavour by long keeping. The substitution of a few gallons of brandy for a portion of the rum, or the addition, after racking, of about 1 oz. each of bruised bitter almonds, cloves, and cassia, the peels of about two dozen oranges, and a thread of the essences of ambergris and vanilla render it delicious.

Whisky.—Dilute alcohol obtained from the fermented wort of malt or grain, as described under "Distillation." That from malt is the most esteemed. The inferior qualities of this spirit are made from raw grain spirit prepared from barley, oats, rye, or rice, and the peculiar flavour so much relished by the lower order of whisky

drinkers is given by the addition of fusel oil. The malt whisky of the Scotch and Irish distillers differs from London gin in flavour, strength, and sweetness.

British brandy, gin, hollands, and rum, are mostly manufactured from the plain or raw spirit of the distiller by the rectifier, who, by the aid of different flavouring matters, prepares the specific spirituous beverage required. English whisky forms no exception to this rule, it being simply plain corn spirit, to which the requisite flavour has been imparted by artificial essences. The peculiar flavour of the Irish and Highland whisky, however, is said to be due to the malt employed in its manufacture, having been dried by means of a peat fire. The mode of distillation also differs from that followed in the English distilleries, since, instead of drawing over the spirit at one operation, the Irish and Scotch distillers submit the first distillate, or *low wines*, to a further distillation. The apparatus is that known as the "pot still," with which it is advisable to use the best malted grain. With Coffey's still, on the contrary, damaged grain may be employed, but the product is a neutral spirit destitute of flavour.

Table *of the Principal Spirituous Liquors sold in England, with their usual Strengths, &c.*

Denomination.	Revenue Mark.	Import Strength.	Legal Limits of Strength.	Usual Selling Strength.	Specific Gravity at 60° Fahr.
Gin (*strongest*) . . .	X.	...	Not weaker than 35 u. p.	10 u. p.	0·9395
Do. { *best* / *ordinary* } . .	X.	...	do.	17 u. p.	0·9445
Do. (*sweetened*) . .	X.	...	do.	22 u. p.	0·
Do. (*low class*) . . .	X.	...	do.	35 u. p.	0·
Do. (*orange*) . . .	X.	...	do.	24 u. p.	0·
Hollands (*imported*)	Geneva.	p. to 10 u. p.	do.	...	0·9358
Rum		About 20 o. p.	Not weaker than 25 u. p.	11 u. p. ...	0·9329 to 0·8597
Rum Shrub . . .	R. Sh.	...	..	64 u. p.	0·
Foreign Brandy . .	F.	About 5 o. p. to 8 or 10 u. p.	Not weaker than 25 u. p.	10 u. p.	0·9318
Spirit of Wine . .	S.W.	...	Not weaker than 43 o. p.	54 to 64 o. p.	0·8415 to 0·8221
Malt, grain, or molasses spirit (*sent out by distillers*)	P.S.	...	...	...	0·8669 to 0·9318
Whisky (*Scotch*, *best*)	P.S.	...	...	Proof.	
Do. (*do.*, *ordinary*)	P.S.	...	Not weaker than 25 u. p.	10 u. p.	
Do. (*Irish*) . . .	P.S.	...	do.	15 u. p.	
Peppermint . . Cloves . . . . Orange Bitters . Raspberry . . . Noyau . . . . Tent . . . . . Aniseed . . . . Caraway . . . Lovage . . . . Usquebaugh . . Ginger Brandy . Cherry do. .	X.	...	...	From 50 to 60 u. p.	1·065* to 1·080

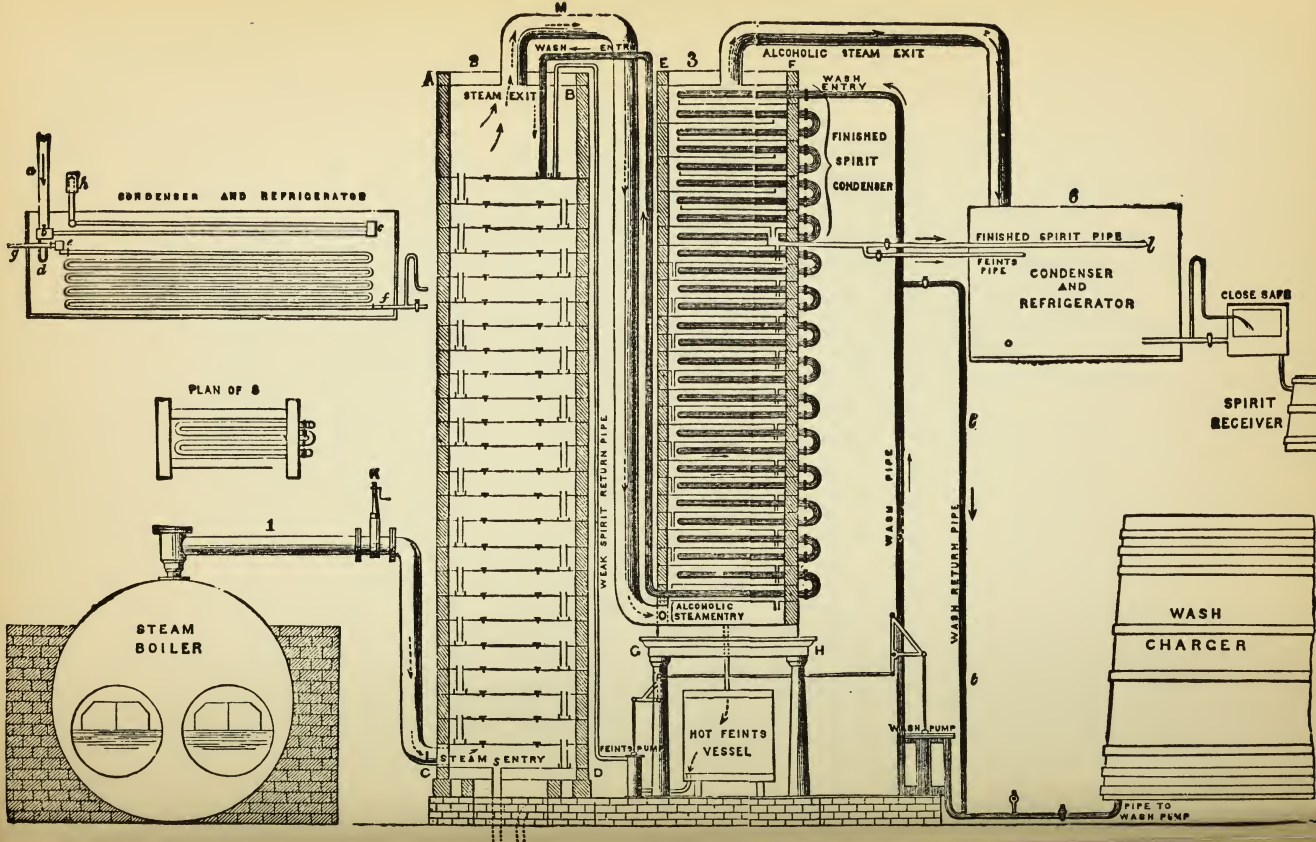
* The specific gravity is no guide when sugar is present.

Stills.—The earlier varieties of distillatory apparatus, including the old-fashioned still and worm, as well as those which were in use previous to the introduction of COFFEY'S machine, possessed the disadvantage of yielding a liquid so poor in alcohol, that, in order to obtain a strong spirit, it was necessary to submit the first distillate to a series of redistillations or rectifications, each of which involved an additional expenditure of time, labour, and fuel. In the later forms of apparatus this redistillation has been avoided, by making the operation a continuous one. This end is gained by causing the vapours on their way from the still to the condenser to become continuously richer in alcohol and poorer in water, so that by the time they reach the condenser they shall consist of strong alcohol only; or, by so cooling the mixed vapours in the rectifier as to condense the greater part of the aqueous portion alone, and thus to separate it from the strong spirit before this last enters the condenser.*

Annexed is a description of some of the principal stills, (the number and modifications of which are almost countless), in use in this and other countries.

COFFEY'S.—Of the various forms of distillatory apparatus, that patented by COFFEY in 1832 is very largely employed in this country. It yields the strongest spirits obtainable on a large scale, and from inferior grain. The spirit so obtained, however, is wanting in flavour. Great economy in the expenditure of fuel is effected by the use of this still, a saving of at least a fourth in this respect being gained when this apparatus is employed instead of the old kind.

* In far the greater number of cases it is customary, with the improved forms of apparatus, to produce at the outset, spirit containing but little fusel oil, and of a strength equal to at least 80 per cent. of alcohol; this is further purified and concentrated by rectification, and then reduced by admixture of water to the strength required for use.—PAYEN.


CONDENSER AND REFRIGERATOR
PLAN OF 6
STEAM BOILER
1
K
A
2
M
WASH ENTRY
STEAM EXIT
B
C
STEAM ENTRY
D
WEAK SPIRIT RETURN PIPE
FEINTS PUMP
E
3
ALCOHOLIC STEAM EXIT
F
WASH ENTRY
FINISHED SPIRIT CONDENSER
ALCOHOLIC STEAM ENTRY
G
H
HOT FEINTS VESSEL
WASH PIPE
WASH PUMP
WASH RETURN PIPE
6
FINISHED SPIRIT PIPE
FEINTS PIPE
CONDENSER AND REFRIGERATOR
CLOSE SAFE
SPIRIT RECEIVER
WASH CHARGER
PIPE TO WASH PUMP

The wash is pumped by the wash pump from the wash charger through the wash pipe into the worm-tube which, it will be seen, extends from top to bottom of the rectifier E, F, G, H. In circulating through this tube it experiences a slight elevation of temperature. Arrived at the last convolution of the worm-tube, the wash passes by the tube I in at the top of the analyzer A, B, C, D. It falls and collects on the top of one of the series of shelves with which this part of the apparatus is fitted till this overflows, whence it falls on to the second shelf, and so on in succession to the bottom. All the time this operation is going on, steam is passing up into the analyzer from the steam boiler through fine holes in the shelves, and through valves opening upwards. As the wash gradually descends in the analyzer it rapidly becomes weaker in alcohol, partly from condensation of steam which is passed into it, and which helps to dilute it, and partly from loss of alcohol, either evaporated or expelled by the steam, till when it arrives at the bottom it has entirely, or almost entirely, parted with the last trace of spirit.

At the same time the vapour, as it rises through each shelf of the analyzer, becomes constantly richer in alcohol, and gradually loses its water because of the condensation of the latter; it then passes from the top of the analyzer in the direction of the arrows, by the pipe M, in at the bottom of the lower compartment of the rectifier, at the spot marked "Alcoholic steam entry." Here it ascends circulating around the worm-tube, until it arrives at J, above which it merely circulates round the top windings of the wash-tube; the low temperature of which condenses the spirit, which, collecting on the shelf at J, flows off by the "finished spirit pipe" into the spirit "condenser and refrigerator," and from that to the spirit receiver.

A still further saving of heat is gained by making the water which supplies the boiler pass through a long coil of

pipe, immersed in boiling spent wash, by which means its temperature is raised before it enters the boiler.

SIEMENS'.—Another variety of distillatory apparatus is that of Siemens' (see page 189), much employed in Germany for the distillation of brandy.

It consists of two mash stills set in a boiler, and capable of being alternately used by means of the three cocks (*a*, *b*, and *c*). L is the boiler; P one of the mash retorts; K is the low wine receiver; R the fore warmer, A a reservoir in which the condensed water intended as feed water of the boiler is collected; C is the dephlegmator; B a reservoir for the vapours condensed in C.

From the dephlegmator the vapour passes to a condenser, not shown in the engraving.

The mash warmer consists of a cylindrical portion (*i i*), the lower part of which has an indentation (*c*). In the cylinder is placed a narrower portion (*o o*) of the real mash-containing vessel fitted with the heating tube (*f*). The upper part of the fore warmer is fitted to the lower part by means of the flange (*h h*); *r* is a stirring apparatus, which is frequently set in operation during the process of distillation. The vapours from the second still are carried into the depression (*c*) under the fore warmer, which in order that the vapours may come into contact with the phlegma, is covered with a sieve.

The vapours surround the under part of the mash reservoir, and enter into the tube (*f*), through which they pass to the lower cylinder of the dephlegmator. The condensed water of the dephlegmator is conducted into the reservoir (A). The upper and under part of the fore warmer are made of cast iron, but the interior bottom and heating surfaces are made of copper. This kind of fore warmer has the advantage of uniformly distributing the heat, while it can be easily cleansed.

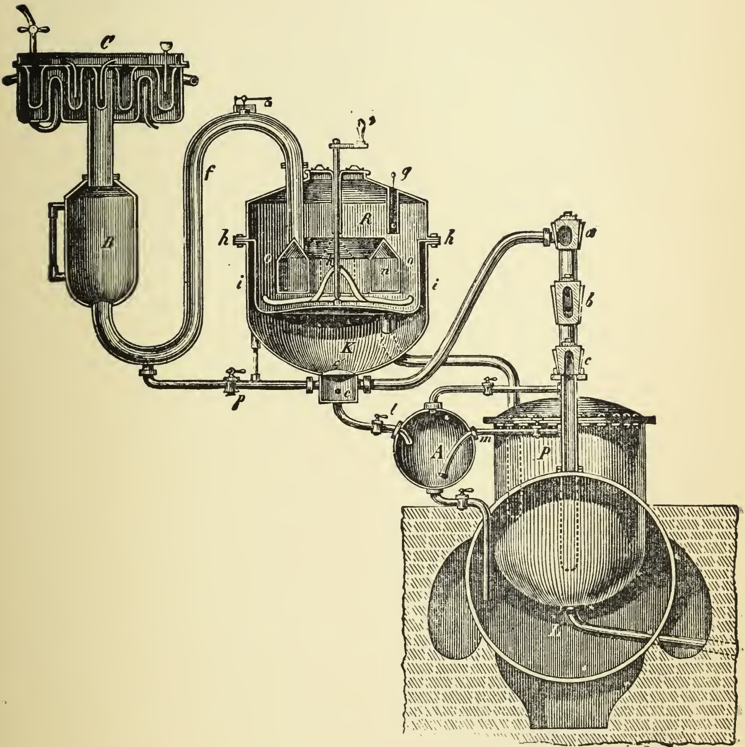


Fig. 9.--SIEMENS' APPARATUS.

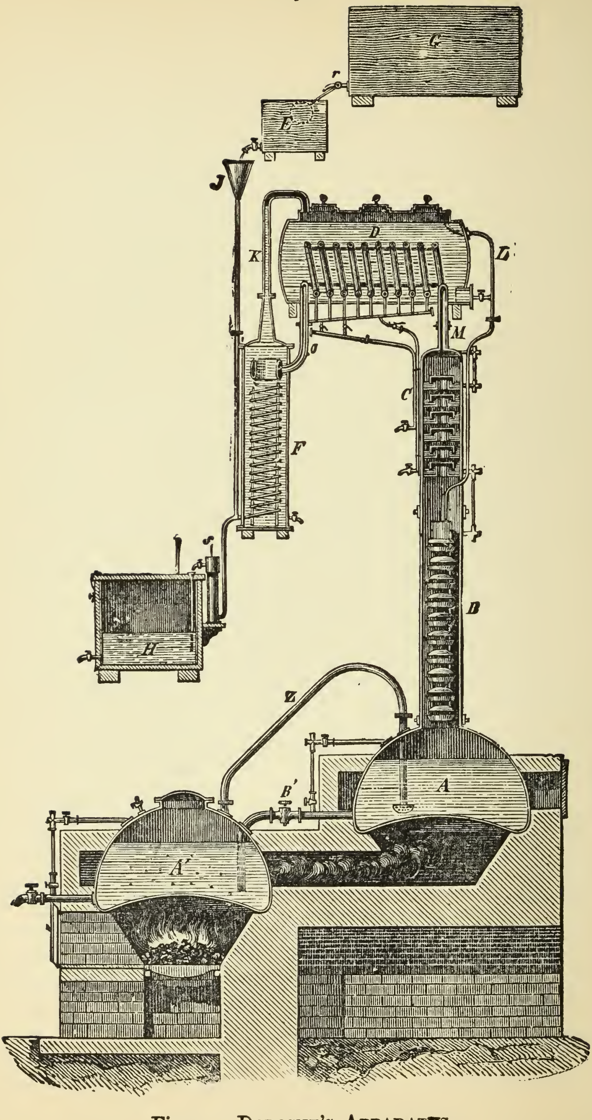


Fig. 10.—Derosne's Apparatus.

The dephlegmator (C) is so contrived that the rectified vapour can be conveyed to the condenser by two separate pipes placed in an opposite direction to each other, which are joined again in close proximity to the condenser.

The remainder of the details will be seen by studying the engraving. It is affirmed that this still is capable of producing 50 per cent. more spirit from potatoes than any other apparatus employed in Germany.

DEROSNE'S.—Another distilling apparatus is that known as DEROSNE'S, which is an improvement upon one invented by CELLIER-BLUMENTHAL. This apparatus is only designed for the distillation of wine, and not, like the previous one, for mash.

The opposite engraving gives a representation of it.

It consists of two stills (A and A′); the first rectifier (B); the second rectifier (C); the wine warmer and dephlegmator (D); the condenser (F); the regulator (E); a contrivance for regulating the flow of the fluid wine from the cistern (G) by means of a floating ball.

The still A′, which, as well as the still A, is filled with wine, acts as a steam boiler. The low wine vapours evolved come, when they have arrived in the rectifiers, in contact with an uninterrupted stream of wine, whereby dephlegmation being effected, the vapour thus enriched in alcohol becomes constantly stronger in the vessel D, and thus arrives at the cooling apparatus (F). In order that a real rectification should take place in the rectifiers the stream of wine should be heated to a certain temperature, which is imparted to it by the heat of the condenser water. The steam from the still A′ is carried by means of the pipe (Z) to the bottom of the still A.

Both stills are heated by the fire of the same furnace. By means of the tube B′ the liquid contained in the still A can be run into the still A′. The first rectifier (B) contains a

number of semi-circular discs of unequal size, placed one above the other, which are so fastened to a vertical centre rod that they can be easily removed and cleansed. The larger discs, perforated in the manner of sieves, are placed with their concave surfaces upwards.

In consequence of this arrangement the vapours ascending from the stills meet with large surfaces moistened with wine, which, moreover, trickles downward in the manner of a cascade from the discs, and comes, therefore, into very intimate contact with the vapours. The second rectifier (C) is fitted with six compartments; in the centre of each of the partition walls, which are made of iron or copper plates, a hole is cut, and over this hole, by means of a vertical bar, is fastened an inverted cup, which nearly reaches to the bottom of the compartment wherein it is placed. As a portion of the vapours are condensed in these compartments, the vapours are necessarily forced through a layer of low wine, and have to overcome a pressure of a column of liquid rather more than $\frac{3}{4}$ of an inch high. The fore warmer and dephlegmator (D) is a horizontal cylinder made of copper fitted with a worm, the convolutions of which are placed vertically. The tube (M) communicates with this worm, the other end of which passes to O. A phlegma collects in the convolutions of this tube, which is richer in alcohol in the foremost windings, and weaker in those more remote; this fluid, collecting in the lower part of the spirals, may be drawn off by means of small tubes, thence to be transferred, at the operator's pleasure, either all or in part, by the aid of another tube and stopcocks, to the tube (O), or into the rectifier.

By means of the tube (L) the previously warmed wine of the dephlegmator can be run into the rectifier. The condenser (F) is a cylindrical vessel closed on all sides, and containing a worm communicating with the tube (O).

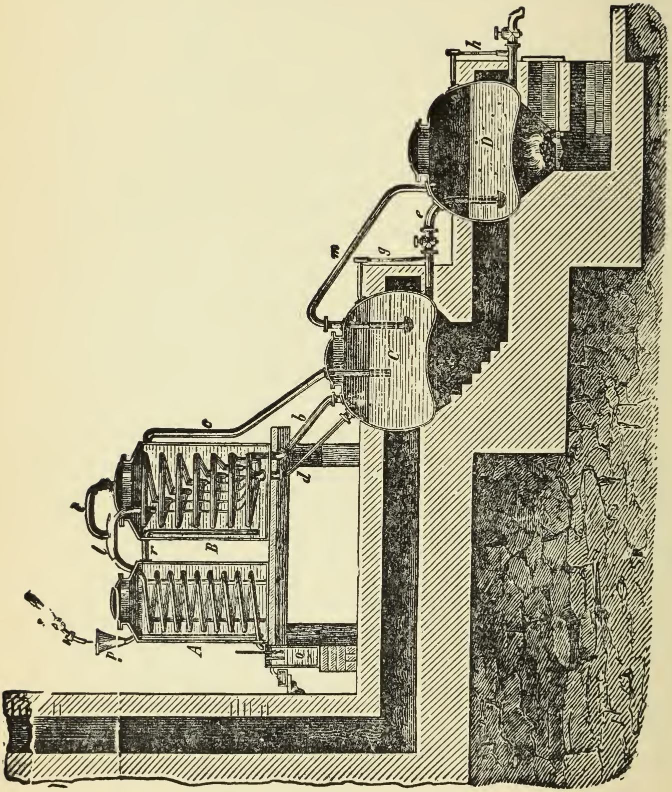


Fig. 11.—Laugier's Apparatus.

The other end of the condensing tube carries the distillate away. On the top of this portion of the apparatus the tube (K) is placed, by means of which wine is run into the dephlegmator. The cold wine flows into the cooling vessel by the tube (J).

LAUGIER's is another variety of distillatory apparatus. It is represented in the accompanying cut.

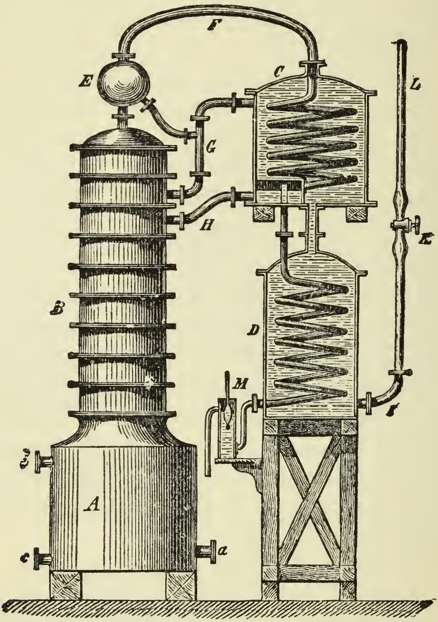
The liquid intended for distillation flows from the tube (*s*) into the funnel (*p*), thence into the vessel (A), entering its lower part, and serving to condense the alcoholic vapour. From this vessel the warm fluid passes by means of the tube (*r*) into the lower part of the second vessel (B), where dephlegmation takes place by means of a condensing tube. From B the fluid flows through the tube (*c*) into the second still (C), which is heated by the hot gases evolved from the fire, kept burning under the first still (D); in the still (C) the fluid undergoes a rectification, and the vinasse flows by the tube (*e*) into the still (D); *m* is the pipe for conveying the hot vapour from D into C; the tube (*b*) carries the alcoholic vapours into the dephlegmator. The tube (*d*) conveys the phlegma into the still (C); *g* and *h* are glass gauging-tubes for indicating the height of the fluid in the interior of the stills; the tube (*l*) conveys the uncondensed vapours from the dephlegmator into the condensing apparatus, while *i* carries the vapours formed in the vessel (B) into the condensing apparatus.

The alcohol condensed in the cooling apparatus flows, as shown in the cut, into the vessel (*o*), provided with a hydrometer, which shows the strength of the liquid. The cooling apparatus of the vessel (B) consists of seven compartments or sections formed by wide spirals, to each of which, at its lower level, is attached a narrow tube, all of which tubes are connected to the tube (*d*), which latter conveys the condensed fluids back into the still.

LAUGIER's apparatus is well adapted for the distillation of every variety of wine, and by proper management may be made to yield brandy of 50 per cent., or alcohol of over 80 per cent. It is largely used in France, not only for the production of brandy, but also of rum.

A very simple form of apparatus in use is that figured below.

FIG. 12.



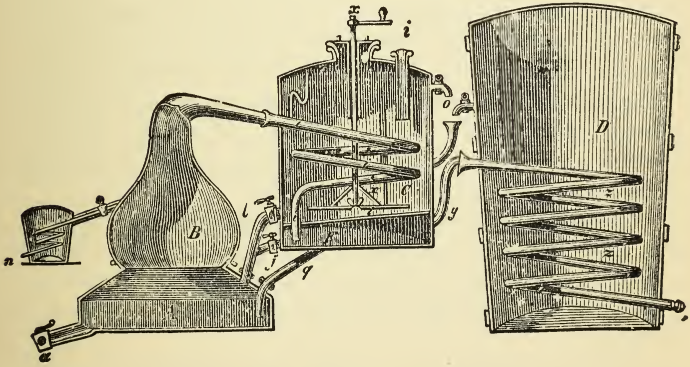
A is a cylinder made of cast iron or copper, in which the fluid to be distilled is heated by a spiral tube made of copper. The inlet of this tube is shown at *b* and the outlet at *a*; *c* serves to carry off the vinasse; B is the dephlegmator, through which the fluid to be distilled continually

flows in a downward direction, while the vapour of the low wine evolved in A ascends uninterruptedly.

The dephlegmator is so constructed as to have as large a surface and as many points of contact as possible. The vapour ascends to the reservoir (E), and passes into the rectifier (C) by the tube (F). The condensed portion returns through the tube (H) to the dephlegmator, while the uncondensed vapour passes on to the condenser of the vessel (D), where it becomes condensed, and is carried off through M. The liquid intended for distillation is kept in a tank (not shown in the engraving), placed above the apparatus, and is conveyed to the latter by the tube (L I), fitted with the stop-cock (K), so that the liquid arrives first in D, is next conveyed to C, thence through G into the dephlegmator, and finally into the cylinder.

DORN's is another form of distillatory apparatus employed in Germany for the distillation of potato-wash, and the

FIG. 13.



rectification of brandy. The use of this apparatus is mostly confined to small works. A is the still, B the capital or head, and D the condensing tub. Between the still and

the latter, is a copper or iron vessel divided into two compartments, C and F. The upper division, C, is termed the "fore warmer," and the lower F, the "rectifier." Attached to the capital is a small condenser *n*, which enables an occasional specimen of the distillate to be withdrawn and examined, as to strength. The vessel C is filled with wash up to the tube, *o*, and is generally made of a capacity sufficient to hold wash enough to fill the still. The revolving arms, *x x*, are for stirring the wash, which thus becomes equally heated to about 190° Fahr., by the vapour passing from the still through the pipe or worm, *i i*. At the commencement of the distillation, the vapour which is condensed in this pipe falls down into the lower division F, and thus constitutes the low wines, or product of the first distillation. As soon as the wash in the fore warmer has reached a certain temperature, the steam in the pipe *i i* is no longer condensed, and the vapours pass over into the low wines in the compartment F, rapidly heating them to the boiling point, and effecting a second distillation or rectification, the vapour or steam from which passing by the tube *y*, is carried to the worm *z z*, and having been condensed into a liquid, runs off at *p* into a receiving vessel. The distillation is continued until what comes over contains from 35 to 40 per cent. of alcohol. When the distillate which collects at *n* is found upon examination to be free from alcohol the operation is finished.

The spent liquid is then run off from the still by the tap *a*, the still being recharged with wash from the wash charger *c*, through the tube *l*, whilst the low wines remaining in F, are drawn off into the still by the pipes *j* and *q*.

The wash worm is then refilled with wash through the tube *i*, and a fresh distillation begun.

PISTORIUS.—This apparatus, which is represented in the

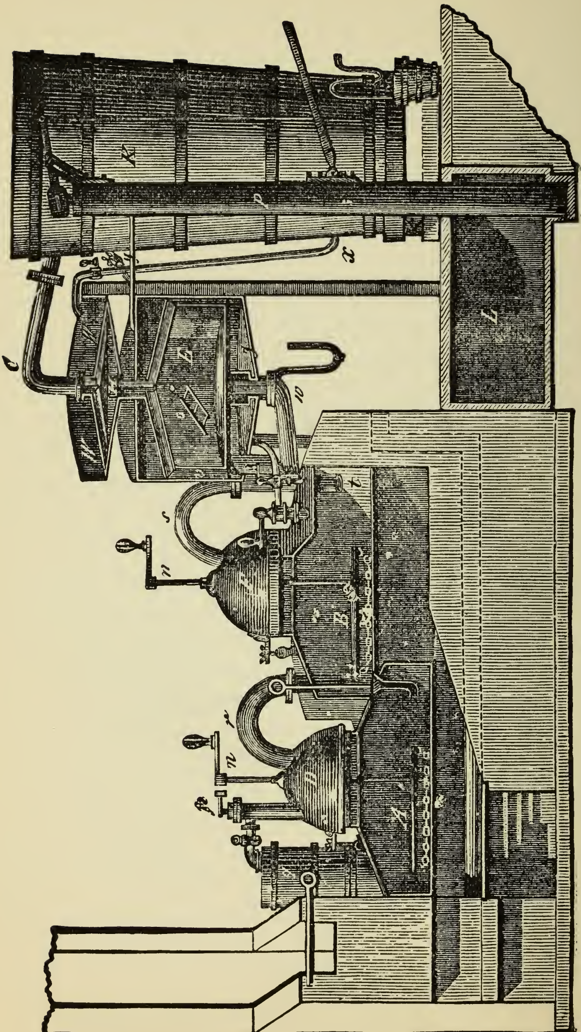


Fig. 14.—Pistorius' Apparatus.

annexed drawing, is largely employed in Germany for the distillation of fermented worts. It produces a very pure and strong spirit, with a small expenditure of labour and fuel. The apparatus consists of two stills, A and B. The contents of these stills are sometimes heated by the naked flame, but preferably by steam-pipes. The fire-grate and flues are shown in the drawing. The main still, A, is fitted with a large head or capital, D, secured to the still by means of bolts and nuts; *p* is a tube projecting from the head, D. This tube is fitted with a safety-valve opening inwards, by which contrivance air can be admitted into the apparatus, in the event of a vacuum being caused in its interior by the condensation of the vapours toward the end of the distillation. The tube, *p*, is also connected with a small condenser, *q*, from which, as in DORN's machine, samples of the distillate can be taken for examination, and the progress of the distillation watched. To prevent the burning of the wort, in both stills are fitted stirring appatuses, *m* and *n*, to which are attached iron chains. The low wine is admitted to the still, B, a tube.

From the head, F, of the still, B, a curved pipe, *s*, conveys the vapour to the fore-warmer, which, as in DORN's appatus, is divided into two parts, the upper, E, containing the wash, the lower, *g* (the "low-wine" reservoir), the vapour ascending along the narrow passage, V, to the rectifying apparatus, H. The vapour is very often conveyed to a third still (not shown in the plate) before entering *g*. The rectifier, H, which consists of two or three conically-shaped vessels, made of sheet-copper and connected together, is provided with a cistern, W, filled with water, and is connected with the condenser, R, by the tube, C. The tube, *x*, conveys cold water to the rectifier, and the short tube, *y*, to the fore-warmer. The pump, P, is employed to raise the wash from the cistern, L, to the fore-warmer, thence it is carried

to the still, B, and from this to A. The steam or vapour from the wash in A passes to the wash in B, which thereby becomes heated to the boiling-point. The still, B, therefore, acts as a rectifier. On the commencement of the distillation the vessel, W, on the rectifier is filled with cold water, which is renewed after it has become heated by the passing vapours.

The true distillation commences as soon as the steam reaches the upper rectifier. The condensed spirit drops into a proper receiver, and its strength is ascertained by means of the hydrometer.

PONTIFEX AND WOOD'S CONTINUOUS WORKING DISTILLING APPARATUS.—This consists of a steam still with an analyzing column, double rectifying apparatus, and condensing worms, as well as of steam-pumps for raising the wash and the cooling liquor. It is made in sizes capable of producing from six to six hundred gallons of proof spirit an hour, from wash obtained from grain, wine, fruit, molasses, and other material. It is said to effect a great economy in the consumption of fuel, as well as of time and labour, and to produce a spirit of any strength or degree of purity in one continuous and uninterrupted operation.

Another form of Steam Still, manufactured by Messrs. PONTIFEX and WOOD, and in very general use, especially in the Colonies, is that shown on p. 205. In this the rectification is effected in the head or upper part of the apparatus.

PONTIFEX AND WOOD'S COPPER FIRE STILL (No. 1).—In this apparatus a retort is interposed between the still and the worm. As by this arrangement a partial rectification only is accomplished, the first distillate has to be redistilled, this particular process being known as the "pot still" system. This still is made of a capacity varying from 50 to 5,000 gallons. (See p. 207.)

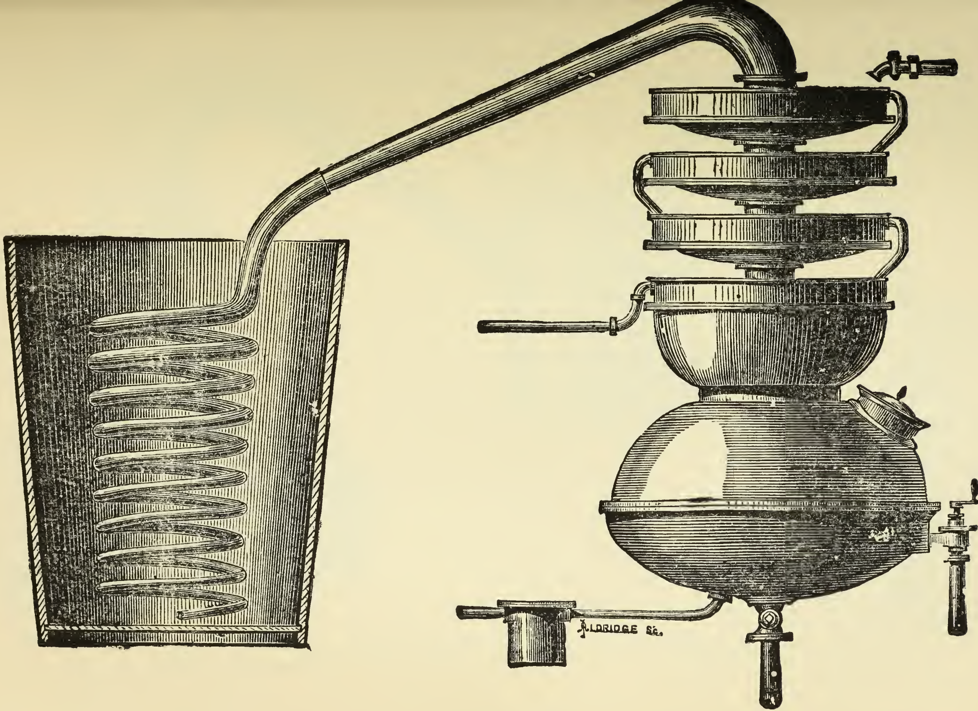


Fig. 15.—Pontifex and Wood's Steam Still and Worm with Rectifying Head.

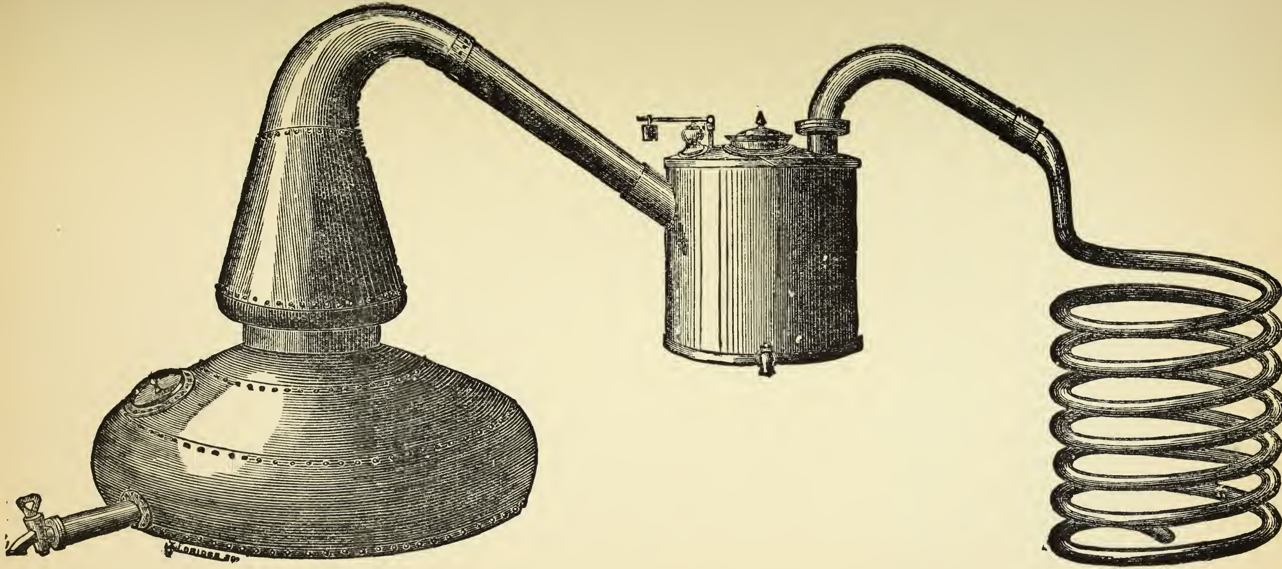


Fig. 16.—Pontifex and Wood's Copper Fire Still (No. 1).

Pontifex and Wood's Copper Fire Still (No. 2).—This apparatus differs from the preceding in having two retorts instead of one. By this contrivance its rectifying power is increased. It is extensively employed in the West Indies for the manufacture of rum, and is said to produce a very superior article.

Pontifex and Wood's Continuous-working Fire Still.—This consists of an analyzing column, a rectifying apparatus, and condensing worm. The still is set in brickwork.

CHAPTER VI.

WINE AND WINE MAKING.

Wine may be described as the fermented juice of the grape, or fruit of the vine—the *Vitis vitifera.* The grape ripens only in those localities which lie between the 25th and 50th degrees of latitude, and where the average summer temperature ranges from 64° to 68° Fahr. (18° to 20° Cent.) Hence in England, which is not situated within these geographical limits, and where the average summer heat is lower than this, the grape cannot be cultivated for wine-making purposes. It comes to maturity, however, in countries having a much less annual mean summer temperature than ours, and where the winters are severe, provided the summers are sufficiently hot.

The vine is found growing in calcareous, clayey, sandy, volcanic, and alluvial districts. It thrives best in a warm loose soil, composed of argillaceous marl, lime, chalk, and gypsum, pervious to air and to water. When transplanted to other countries, the vine, although cultivated under conditions as to soil and sunshine, nearly the same as in its native habitat, produces grapes, the wines made from which frequently possess nothing in common with the wines of the mother country. Thus, wines so opposite in character as those of Burgundy, the Cape, and Spain, are obtained from the fruit of vines all belonging to the same stock, and indigenous to Burgundy.

The wines of Italy and Greece possess little in common,

yet those of the former country are derived from grapes grown on vines originally exported from Greece, and the Bucellas of Portugal is obtained from the grape of the Riessling, a vine the native country of which is Germany.

An excess no less than a deficiency of water is unfavourable for the growth of the vine. Every vineyard should be so contrived as to carry off the superfluous water during wet seasons, and to retain it during droughty ones. Those vines thrive best when the water, instead of being retained on the surface, is within a few feet of it, and easily accessible to the roots. In Médoc the vines are reared on small hillocks, composed of an artificial gravelly soil, into which, when it falls, the rain quickly sinks, not without leaving its fertilizing ingredients to be absorbed by the spongioles of the root, and at the same time making way for a fresh supply of atmospheric air. A soil that is too calcareous requires tempering with sand, or preferably with disintegrated granite, if this can be procured; too sandy a soil should be mixed with clay marl, and all sandy and clayey soils with gypsum and chalk, judiciously applied. When a clayey soil is of so adhesive a nature as to prevent the access of air, or retains water too tenaciously, it should be partially burnt or mixed with burnt clay.

The manure usually employed in the vineyard is that obtained from the stables of horses, cows, mules, and donkeys, the dung being the more valuable the richer it is in urinary constituents. The manure is applied in as fresh a condition as possible; but must not be dug into the ground until after the vintage. When this is done it is important that it should not come into direct contact with the vine or its roots.

Instead of stable manure, the French viticulturists sometimes have recourse to a compost of grape marc and lime, powdered bones, woollen rags, horn shavings, and bullocks' and sheeps' blood diluted with ten times the quantity of

water. They also use rape-seed mash, it being more economical than animal dressing.

Human excrement is sometimes used; but as manures abounding in ammoniacal ingredients are apt to lead to an overgrowth in the branches of the vine, as well as to act detrimentally to the fruit, caution is required in its application. As the grape juice contains a considerable amount of potash, which the vine abstracts from the earth, the viticulturists must remedy the deficiency if necessary by keeping the soil properly supplied with this essential ingredient. For this purpose the Stassfurth Salt, which contains from 13 to 17 per cent. of chloride of potassium, will be found a useful and economical application. In many parts of Burgundy, marc is used in the manure.

The different varieties of grapes cultivated in wine-making countries, each of which yields a distinct kind of wine, amount to some thousands.

In France, as long back as 1827, there were, according to CAVALOW, more than 1,500 different wines, and since then the number has increased considerably. The principal wine-producing districts of France are the ancient provinces of Auvergne, Burgundy, Champagne, Dauphiné, Gascony, Guienne, Languedoc, Lyonnais, Provence, and Roussillon.

Some of the choicest and most renowned French wines are obtained from vines grown in the Gironde.* From that portion of the department known as the *Médoc*, come most of our most esteemed clarets. The finest of these wines are named after the vineyards and estates, where the fruit from which they are made, is grown. They are divided into classes. The first class comprises *Château Lafitte*, *Château Latour*, *Château Margaux*, and *Château Haut Brion*; the second and third *Léoville*, *Mouton*, *Rothschild*, *Lagrange*, &c.

* In 1855, the wines of the *Gironde* were arranged by a syndicate of brokers into various classes, comprising five growths.

Of the white wines of the Gironde, the most valuable are those made from the grapes of the *Grave*, a sandy district near Bordeaux. The principal Grave wines are *Sauterne*, *Barsac*, *Preignac*, and *Bommes*, the chief of which are *Château Yquem* and *Château Latour*. The wines of Burgundy are the produce of grapes reared on the low chain of hills running from Dijon to Macon, in the department of the Côte d'Or.

The most celebrated Burgundies are: *Romanée Conti*, *Chambertin*, *Richebourg*, *Clos Voujeot*, *Clos St. Georges*, and *La Tache*. The Burgundy wines bear export well, but do not keep when bottled as well as clarets. The Dauphiné and Lyonnais wines which, like those of Macon and Burgundy are also of high quality, are *Hermitage*, *Greffeux*, and *Meal*.

French red wines of second quality are mostly produced in Champagne, Beaujolais, Roussillon, and the northern slopes of the Pyrénées, as well as in the districts before specified.

The finest Champagne comes from the department of the Marne.

Spain produces an almost infinite variety of wines, amongst the best known of which are the wines of Xeres or *Sherry*, the produce of the vineyards of Andalusia; *Malaga* from Murcia and Grenada; *Catalan* or *Spanish Port* from Catalonia.

Besides the port produced in the vineyards of the Alto Douro, the best known wines of Portugal are *Lisbon* and *Bucellas*.

A few of the innumerable wines produced in Germany may be mentioned. *Hock* made from grapes grown at *Hochheim*, on the Main; the wines of the Rheingau, *Johannisberg*, *Steinberg*, *Marcobrünner*, *Rudesheim*, *Liesten Riessling*, *Assmanshausen*, *Geisenheim*.

The Ahn is a great wine-growing district, and produces

the wines of *Walportzheimer* and *Ahrbleichart*, which have a large local consumption. From the Moselle vineyards come *Zettingen*, *Piesport*, and *Brauneberg*. *Sparkling Moselle* is manufactured from a Moselle grape, to the juice of which cane-sugar is added. The muscatel flavour is due to its impregnation with elder flowers. In Italy, Austria, Styria, Bohemia, Greece, and Hungary, Madeira, the Canaries, and South Africa, the vine is also largely cultivated, as well as of late years in America and Australia.

In planting the vine, those varieties only should be taken which yield grapes that produce the best wines; nor should any other plant or fruit, beside the grape, be cultivated in the vineyard. In general a vine obtained from the seed is three years before it bears fruit.

The vineyard should be kept persistently free from weeds, and the vine from dead or useless branches. The soil of the vineyard should never be opened during a frost, or while it is snowing, or hail is falling. To protect the vines from the injurious effects of spring frosts, night frosts in early summer, cold rains, and hail, Guyot introduced what has since proved to be the successful plan of covering them with straw matting. The mats are placed over the plants on the 1st of November, and removed on the 1st of April. They are so arranged that the vines shall, if possible, be exposed to an east and south aspect, scarcely at all to the west, and not at all to the north. When the vines are attacked by *oïdium*, the grower dusts them over plentifully with flowers of sulphur, using 20 kilograms (about 44 lbs.) for each hectare (about $2\frac{1}{2}$ acres) of vineyard.

Amongst the numberless remedies that have been suggested and tried by the foreign viticulturists, with varying but by no means uniform or satisfactory results, for the destruction of the *Phylloxera*, may be mentioned sulphur, the sulphites, tobacco, caustic soda, and potash, bisulphide of carbon, coal-tar, soft soap, lime, sulpho-carbonate of

potassium, and sand. Submergence of the vineyard has occasionally been had recourse to.

A certain amount of success has been said to have attended the employment of the sulpho-carbonate of potassium and sand.

Wine Making.—The grapes are not removed from the vine until they are quite ripe. As the maturation not only of different varieties, but of the same kind, is dependent upon the season, no stated period can be fixed for the commencement of the vintage. The grapes are ready to be gathered when the white kind becomes of a brownish yellow colour, and the red or blue, very dark purple or nearly black.* Shears, pruning-knives, or scissors, are used for the removal of the fruit from the vine.

In making the finer wines, previous to being pressed, the bunches are carefully examined, and any unripe or damaged grapes are picked off and used to make inferior wine, or in the gathering the unripe specimens are left on the branch to ripen. The blue and dark varieties, when intended for the best wines, are, with few exceptions, removed from the stalks before being pressed; the white grapes are pressed with the stalks.

Except with those grapes which produce wines that are likely to become viscous or ropy, the stalks are not left for any length of time in contact with the grape juice or must. There are various modes of separating the grapes from the stalks. One method consists in the employment of a wooden fork or trident, half a yard or more in length; by turning this round in a wooden pail filled with the fruit, the grapes become detached from the stalks, which are thus brought to the surface and removed.

In another contrivance the separation is effected by en-

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* Grapes grown in a soil poor in manganese are said to be deficient in colour.

closing the bunches in cages made of parallel wires. Inside the cage there is a stirrer; when this is turned by an external handle, the grapes alone drop through the wires, leaving the stalks in the cage. Sometimes the separation is accomplished by means of hurdles, which are so manipulated that the fruit only shall pass through the meshes.

Previous to their being pressed, the grapes have to undergo the preliminary process of bruising or crushing. This is sometimes done by their being trodden under the naked feet of men, on a large wooden stage or platform; at other times the men wear heavy boots, whilst in some cases the grapes are placed in a vat and bruised with a kind of wooden pestle. Sometimes they are crushed between wooden grooved rollers. Of all these processes, the first, although the least cleanly, possesses the advantage of not crushing the pips or stalks, and is thus free from the risk of imparting an unpleasant flavour to the wine.

There is considerable divergence in the statements of different writers as to the yield of must or juice from ripe grapes. PAYEN says it amounts to from 94 to 96 per cent. of the total weight of the grape. DUPRÉ and THUDICHUM obtained from three samples of grapes respectively, 78·75 per cent., 76·75 per cent., and 72·25 per cent. WAGNER averages it from about 60 or 70 per cent..

CLASSEN obtained from 1,000 parts of the ripe fruit in 1868—577 to 668 parts of juice. On analysis this was found to yield:—

Water	860 to 830 parts.
Sugar	150 „ 300 „
Pectin. gums, extractive matter, protein substances, organic acid, and mineral matter	30 „ 20 „

Two samples of juice—the one from Neroberger and the other from Steinberger grapes—grown in 1868, examined by NEUBAUER, contained in 100 parts:—

	Neroberger. (Large Grapes.)		Steinberger. (Selected Grapes.)
Sugar[1]	18·06	...	24·24
Free acid	0·42	...	0·43
Albuminous substances[2]	0·22	...	0·18
Mineral constituents (potash, phosphoric acid, &c.)	0·47	...	0·45
Combined organic acids and extractive matters	4·11	...	3·92
Total of soluble constituents	23·28	...	29·22
Water	76·72	...	70·78
	100·00	...	100·00

Another analysis of the juice of ripe grapes grown on the Rhine in 1868 gave in 1,000 parts:—

	1.		2.		3.
Solid matter	164·4	...	189·7	...	204·6
Sugar	149·9	...	162·4	...	174·0
Free acid	7·2	...	6·8	...	4·8
Ash[3]	2·7	...	3·0	...	4·0

[1] The sugar consists of a mixture of dextrose and levulose. Sometimes it forms as much as 30 per cent. of the whole contents of the grapes, and seldom less than 12 per cent.

From experiments made upon growing grapes, it appears that, whilst the percentage of sugar increases with the gradual maturation of the fruit, its acid constituents at the same time diminish. This is exemplified in the following table, which records the results of several analyses of Neroberg grapes grown near Wiesbaden. The examination was made by Neubauer, a German chemist, in 1860.

	Per cent. of Sugar.		Per cent. of Free Acid.
On July 27th, the grapes contained	0·6	...	2·7
,, August 9th, ,, ,,	0·9	...	2·9
,, ,, 17th, ,, ,,	2·3	...	2·8
,, ,, 28th, ,, ,,	8·2	...	1·9
,, September 7th, ,, ,,	11·9	...	1·2
,, ,, 17th, ,, ,,	18·4	...	0·95
,, ,, 28th, ,, ,,	17·5	...	0·8
,, October 5th, ,, ,,	16·9	...	0·8
,, ,, 12th, ,, ,,	18·6	...	0·9
,, ,, 22nd, ,, ,,	17·9	...	0·9

From statements similar to these, the conclusion has been

When a white wine is required, the bruised grape, whether of the white or red variety, is at once pressed, except when, as happens with some kinds of fruit, it is kept to allow of the development of the bouquet. The mode of procedure is different when a red wine is to be prepared. The crushed grapes must then be kept in a tub or vat, loosely covered over, until an examination of a small quantity of the juice

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frequently drawn that the free acid in the grape becomes converted into sugar. Drs. DUPRÉ and THUDICHUM, however, dispute this deduction, and contend that, as during its growth the grape gains greatly in weight, not only would this increase considerably lessen the proportion per cent. of the ripe over the unripe fruit, but that the total quantity of acid might really be greater in the former than in the latter. They claim to have established by experiment that during its ripening there is frequently no decrease in the total amount of acid in an entire grape, or if there be, that it is only trifling.

[2] The albuminous and protein compounds constitute the nutriment of the yeast-cells, these latter being precisely the same as the yeast fungus of beer.

[3] CRASSO got from the juice of a bunch of ripe grapes ·326 per cent. of ash. The ash obtained by the same chemist from four varieties of grape-juice had the following composition:—

Matters contained in the Ash.	Must 1. From unripe black grapes.	Must 2. From ripe black grapes.	Must 3. From ripe black grapes.	Must 4. From ripe white grapes.
Potash	66·334	65·03	71·852	62·745
Soda	0·329	0·423	1·205	2·659
Lime	5·204	3·374	3·392	5·111
Magnesia	3·276	4·736	3·971	3·956
Iron oxide	0·729	0·427	0·091	0·403
Manganese oxide	0·820	0·747	0·098	0·305
Sulphuric acid	5·194	5·554	3·654	4·895
Chlorine	0·745	1·029	0·474	0·700
Silica	1·991	2·099	1·190	2·182
Phosphoric acid	15·378	16 578	14·073	17·044
	100·000	100 000	100·000	100·000

shows it has acquired the necessary colour. For it to do this sometimes takes from three or four days to a month.

During this period, alcohol has been formed in the pulp, and this, with the tartaric acid of the fruit, has dissolved out the colouring principle of the grape. Great care is necessary at this stage to prevent the too long exposure of the crushed and fermenting fruit to the air.

Wine presses are of various patterns. The most primitive form is the "hurdle press," constructed only of hurdles and heavy stones.

Lever and screw presses are also in very general use. In some of the former the pressure is applied by a heavy wooden lever, 40 or 50 feet long. In many lever presses the pressure is from below. The screw press is upon the principle of the bookbinder's. The plate used for applying the pressure has a rim, which collects the expressed juice and carries it off. In ORTHLIEB'S press, an iron cylinder is used instead of a flat plate.

The principle of WENIGER'S machine is the equal application of the pressure. This is acomplished by means of two pistons, one working at the top and the other at the bottom of the apparatus.

In many wine-making establishments, iron presses have supplanted wooden ones, over which they possess the advantages of greater cleanliness and non-absorption of the must. The wine-press in general use in the Gironde consists of a tall round basket, made of perpendicular laths. The fruit is placed in this basket, and upon the fruit a wooden block, to which a screw is attached; a nut works upon the screw from above downwards, and presses the wooden block upon the fruit, the liquid from which is forced out through the laths and collected.

In the manufacture of champagne and some red wines,

very powerful presses are employed; but these possess the objection of pressing the fixed oil from the pips and an unpleasantly tasting juice from the stalks, and thereby damaging the product. In some establishments, centrifugal machines have been used, not only with the result of yielding a better wine, but of effecting a considerable gain in time and labour. In 1862, STEINBEIS and REIHLEN in ten minutes, expressed the juice perfectly from 100 to 120 lbs. of grapes, including the time required for filling and emptying the machine; and in 1869, BALLARD and ALCAN obtained the following results:—

	Centrifugal Machine.		Press.
Must	79·141	...	77·086
Residue	20·214	...	18·601
Loss	0·645	...	4·313
	100·000	...	100·000

The must, being received into proper receptacles, next undergoes the vinous fermentation. In the case of white wines the must is kept separate from that subsequently procured by submitting the husks, pips, and stalks to additional pressure, and is sold as the "first" or superior wine.

But with red wines the husks (and in some cases the marc) are thrown into the fermenting vat, by which means the wine acquires an additional amount of colouring matter. In this case, when the completed wine is drawn off, the husks are again pressed, and the wine so obtained added to the first instalment. As the tannic acid is derived from the skins and seeds of the grape, wines prepared in this manner usually contain a considerable amount of this substance.

The fermentation is conducted in different countries at different temperatures, and, of course, with different results. When must is fermented at 15° to 20° Cent. (59° to 68°

Fahr.) it yields a wine strong in alcohol, but wanting in bouquet; whilst if the fermentation be carried on at 5° to 15° Cent. (41° to 59° Fahr.) the product will be a wine rich in bouquet, but poor in alcohol.

The wines of Spain, the South of France, Austria, and Hungary, are produced at the higher temperature, and those of Germany, for the most part at the lower one. The fermentation is carried on in large wooden vats. In some places vats of sandstone or brick are used for this purpose. The fermentation of white wines, such as those of the Rhine and Gironde, is effected in new and perfectly clean casks or hogsheads, the bungholes of which are left open to allow of the escape of the carbonic acid. Opinions differ as to whether air should be admitted or not during fermentation. The process is undoubtedly quickened if the must be aërated. The aëration is sometimes performed by a bellows fitted with a rose nozzle. During the operation of blowing in, the must is to be kept at a low temperature, to prevent the volatilization of the bouquet. When the opposite method is followed, various devices are in use for excluding the air, or at any rate an excess of it. In some cases the vat, being provided with a suitable lid, has a hole, or is arranged with a tube, for the escape of the carbonic acid. Koles and Bamberger accomplish the same end, without letting in the external air, by means of a glass tube bent twice at right angles; one limb of the tube passes through the bunghole into the wine, and the other, or outer limb, into a vessel of water. In another contrivance the lid of the vat is fitted with a valve, which, opening only outwards, allows of the exit of the carbonic acid.

Red wines are fermented in large and, in most cases, open vats, fitted in the inside with perforated shelves, which, being below the surface of the liquid, prevent the

husks rising to the top, and setting up acetous fermentation. After the completion of the fermentation of Burgundy wines, in some places it is the filthy custom for men to enter the vat, and by their vigorous movements to mix the contents.

It is satisfactory to learn that this particularly objectionable practice is getting somewhat into disuse.

The length of time necessary for the completion of the fermentation varies with the locality, the temperature of the apartment, and with the quality of the wine required. In France, for the ordinary descriptions of wine, it generally takes from three days to a week, and in Germany from one to two weeks; with the finer kinds of wine it occupies four, five, or six weeks. The progress of the fermentation may be estimated from the specific gravity of the liquid, since as the fermentation proceeds, and the sugar is undergoing conversion into alcohol, the wine, of course, becomes more attenuated and its specific gravity diminishes. It has been calculated that half per cent. of the alcohol present in the wine escapes during fermentation, as well as a considerable quantity of carbonic acid. An apparatus has been invented for collecting these products, by causing them to pass into water by means of an hydraulic bung.

When the fermentation is over the wine is run into casks, any sediment, such as lees or yeast, being left behind in the fermenting vessel. It is most important that the casks used for this purpose should be absolutely clean. Before a cask is used a second time it should be thoroughly sulphured.

Those wines which contain a large amount of alcohol are sometimes allowed to remain in the fermenting vat until they have cleared; but weak wines are immediately drawn off into the cask, to prevent the setting-in of the acetous fermentation. The casks must be filled to the bungholes.

A second or minor fermentation takes place in the wine when in the cask, during which tartar or bitartrate of potash is deposited on the sides of the cask, and yeast at the bottom. This second fermentation should be allowed to go on at a low temperature, 5° to 10° Cent.* (41° to 50° Fahr.), and at a slow rate. In some cases it is made to extend to three or six months.

When the second fermentation is over, the casks are filled to the bunghole and securely closed, or the wine is at once drawn into fresh casks to be stored. In these it remains closely bunged up until more tartar is deposited, after which it may be racked off into bottles or casks. When wine is to be stored for any length of time it is necessary to repeat the racking off frequently. Racking is performed by means of a siphon inserted in the bunghole, or by a cock suitably fixed in the cask. If the racked wine is not perfectly clear, it is fined by the addition of isinglass, previously softened by soaking in a small quantity of wine. After the addition of the isinglass, the cask is then filled to the bunghole, closed, and remains undisturbed for about six weeks, and if, at the end of that time, it is not perfectly bright it is made to undergo a second racking. In wine-making countries, blood and solution of glue are sometimes used for fining red wines which contain much tannin. Milk is also occasionally employed for the same purpose. The racking should be performed in cool weather, and preferably in the early spring.

The manufacture of champagne differs in its details from that of the so-called "still wine." The best wine is made from a black grape of very fine quality, known as the *Noirien*, or *Pineau*, and grown in the champagne district.

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* Payen.

None but the best selected grapes are used; all those that are rotten, unripe, or in any way unsound, being rejected. The grapes are gathered when they have attained their greatest size. The vintage commences early in October. To prevent the juice being coloured by the skin of the grape, the fruit is submitted to pressure as quickly as possible after being gathered. Very powerful machines are employed for this purpose, since the champagne grape, unlike other varieties, is not previously crushed. Great care is taken to apply the pressure evenly and to conduct the operation with all expedition, for if this exceeds two hours the must will be coloured. The grapes are sometimes pressed four times. In good seasons the must obtained from the different pressings is mixed together. In middling ones the first yield is kept for making the best wines, nor is the fourth mixed with the other two. The light-coloured must is first conveyed into a large vat, where it remains for six, twelve, or eighteen hours, according to the temperature.

At the end of this time certain vegetable matters that would damage the taste of the ensuing wine, as well as render it liable to a second fermentation, become deposited. Directly the must has cleared, it is run into small barrels of 2,000 litres* capacity, in which it undergoes fermentation. Sometimes the clearing of the juice is accomplished by filtration; at others, when the weather is warm and fermentation sets in so rapidly as not to allow the impurities to subside, it is run into casks filled with the fumes from burning sulphur; by this means the excessive fermentative action is arrested, and sufficient time is given for the dregs to settle. The juice having been made clear by either of the above methods,

* A litre = 1·76377 pints.

is drawn into barrels, which are arranged in rows in the cellars. The barrels are filled to the bung, the froth which is formed during the fermentation flowing out at the bung holes. In some wine-making establishments, the barrels are tightly bunged up, there being previously added to the contents 1 per cent. of brandy. The casks are opened at the end of December, and the wine fined by means of isinglass; this operation being conducted at the lowest possible temperature. If, at the end of a fortnight, it has not become bright, it is left for another fortnight, and then, if not clear, it undergoes a second fining. The fining process must be used with caution; when overdone it diminishes, and frequently stops, the activity of the subsequent fermentation. To obviate this, the wine should be judiciously exposed to the air, and a minute quantity of yeast added to each hogshead before it is bottled.*

When the wine has cleared, before being bottled, cane sugar is added to it, since the quantity of undecomposed natural sugar in the wine is not sufficient to furnish the requisite amount of carbonic acid gas, the ingredient to which champagne owes its effervescent properties.

Champagne bottles constitute a very considerable item in the trade expenses of the wine-maker. He pays the glass manufacturer 28 francs a hundred for them; and some wine makers give orders for as many as from 50,000 to 350,000 at a time.

The bottles as they arrive are examined by an experienced person, and those which contain flaws of any kind, or are not perfectly new, symmetrical, and strong, are rejected. These average about 10 per cent. The bottles are required to be as nearly as possible of uniform weight and thickness.

* "A teaspoonful to the hogshead." Dupré and Thudichum.

The inside of each bottle is scrubbed by means of a revolving hair brush and clean water. After being drained, the bottles are rinsed with spirit of wine, and closed with an old but clean cork. They are thus ready, when required, for filling. The wine maker also expends a large amount of money in the purchase of corks, which must be of the best and soundest description. It has been found to be very false economy to use inferior kinds. The wine being drawn into bottles to a height of 2 or 3 inches from the top of the neck, the bottles have next to be corked, the cork being secured in the bottle by a small iron band, called an *agrafe.* All these operations have to be performed deftly and rapidly by experienced workmen. With what speed they are accomplished may be imagined from the fact that an *atelier* of five workmen, who divide the labour, will bottle and cork from twelve to fifteen hundred bottles daily, two bottles passing through all hands in one minute.* The corking, &c., finished, the bottles are next placed *on their sides,* and stacked in cellars or caves, each stack being supported by thin laths.

As the summer approaches, the wine begins to show signs of fermentation, which increases with the hot weather. When the fermentation reaches such a stage as to cause the wine to occupy the previously unfilled space in the neck of the bottle, a large number of bottles begin to burst, as well as to leak; and in some years as much as 30 per cent. of the wine is lost from these causes. Two courses, each of which requires to be promptly adopted, are open to the wine maker under these circumstances. Either he must remove the wine to a cooler cellar, or uncork the bottles. Sometimes, if the breakage, or *casse,* as it is termed, has not exceeded 7 or 8 per cent. by the time August is reached, he takes the

* Dupré and Thudichum.

chance of further loss, and lets the wine remain, for with the fall in temperature which usually occurs in September and October, the energetic action of the wine ceases, and the breakage also.*

The leaky and broken bottles are then removed from the sound ones, which are restacked and left until a yeasty substance has discontinued depositing upon their lower sides. The bottles are kept in this condition until required for sale. Before, however, they are in a fit state for the purchaser, the yeasty matter has to be removed, and the wine to be liqueured. The yeast is got rid of as follows:—The bottles are placed neck downwards, on perforated shelves arranged in rows. A workman then seizes a bottle, and holding it in the inverted position, by a dexterous movement discharges the yeast from the side and brings it down upon the cork. This operation, which extends over some weeks, has to be

* To reduce the serious loss arising from this cause, many wine makers have recourse to a manometer or pressure-gauge. By fixing this instrument on the neck of a few bottles, and examining its readings, the extent of pressure that is going on at any time can be ascertained, not only in the bottles to which it is attached, but in every one of the others belonging to the same batch of wine, provided they have been stored under the same conditions as to temperature, &c. When the instrument approaches danger-point, the bottles are removed to a cooler cellar. SCHINZ's manometer is a very useful form of apparatus. Sometimes the excess of pressure may be overcome by placing the bottles in an upright position, when some of the gas will escape between the neck and the cork.

According to Messrs. DUPRÉ and THUDICHUM, the amount of pressure of gas in a bottle of champagne should be from $4\frac{1}{2}$ to 5 atmospheres; below this the wine is deficient in effervescence, whilst at 7 or 8 atmospheres the bottles are in danger of bursting. Minute instructions enabling the manufacturer to turn out a wine of the above standard of pressure, together with a formula for calculating the quantity of sugar required to produce it, are given in Messrs. DUPRÉ and THUDICHUM's work:—"A Treatise on the Origin, Nature, and Varieties of Wine," published by Macmillan & Co.

repeated from time to time, until the supernatant wine is quite clear. The bottles are then very cautiously removed from the cellars to the corking and tying-down rooms, when they come into the hands of a workman called a "disgorger." The disgorger, holding the bottle still neck downwards, proceeds to liberate the cork, by slipping off the *agrafe*, and when the cork is three-parts out he quickly inverts the bottle. The cork is then forcibly ejected with a loud report by the froth, which carries with it the greater part of the yeast and other solid matters, what remains of these being got rid of by the workman working his finger round the neck of the bottle, whereby they are detached, and forced out by the still rising froth. The workman then places his thumb over the mouth of the bottle, which is afterwards temporarily closed with an old cork.

The liqueur, which is next to be added, is of very varied composition, as almost every champagne maker has his favourite and special preparation.

The best liqueurs are made of some choice wine, mixed with the purest cane sugar. The inferior kinds consist of a mixture of spirit of wine, sugar, and some flavouring material. A certain measured quantity of the liqueur is added to each bottle of wine. The bottle is then corked, wired, tied down, and washed, and the cork covered with tin-foil, and labelled. It is then ready for sale and export. It sometimes happens that after the previous round of operations have been gone through, the champagne becomes turbid, and a minor second fermentation sets in. In this case, it is made to undergo a repetition of the processes already described. It is a desideratum with every champagne maker that when the bottle is opened for its contents to be drunk, the removal of the cork should be accompanied with a full, deep, and distinct report.*

* According to the strength of the effervescence, champagne is distinguished as *Mousseux*, *Demi-Mousseux*, and *Crémant;* the

When, instead of this, the report is short and sharp, and resembles a popping noise, this is owing to the space between the liquid and the cork, filled with the gas, being too small. When the gas escapes with a hissing noise, it is because the cork fits the neck of the bottle unequally, or has not been driven in in a perfectly straight direction. The good name of any maker would be seriously damaged were he to send out champagne liable to comport itself in this manner. He therefore spares no expense in providing himself with the very best and soundest corks. The best way to prevent the escape of the gas from the bottle is always to keep the bottles lying on their sides.

All effervescing wines are manufactured in a similar manner to champagne.

Since the alcohol in the wine is derived from the sugar contained in the must, it would seem that the sweetest and ripest grapes should yield the strongest product. When the decomposition of the sugar has been complete, this will be the result; but it frequently happens that, owing to an insufficiency in the must of the protein compounds which nourish the yeast-cells (the *torula cerevisiæ*), by the agency of which the fermentation is accomplished, the whole of the sugar is not converted into alcohol, in which case a sweet wine will be produced; or the sweetness may be due to the alcohol formed stopping the fermentation before all the sugar had been decomposed, or to an excess of glycerin. If, on the other hand, the grape juice is rich in albuminous matter, but poor in sugar, the consequent wine will be what is termed a "dry" one. Such are the red wines of France and the Rhine.

Mousseux being the most highly charged with gas, and the *Crémant* (so called from its presenting a creamy surface) the least so. *Demi-Mousseux* is intermediate between the two.

TABLE—*Showing the Quantity of Alcohol in Wine.*
DR. CHRISTISON.

Name, &c.		Alcohol of ·7937 per cent. by weight.	Proof spirit per cent. by volume.
Port	Weakest	14·97	31·31
	Mean of 7 samples	16·20	34·91
	Strongest	17·10	37·27
	White	14·97	31·31
Sherry	Weakest	13·98	30·84
	Mean of 13 wines, excluding those very long kept in cask	15·37	33·59
	Strongest	16·17	35·12
	Mean of 9 wines long kept in cask in the East Indies	14·72	31·30
	Madre da Xeres	16·90	37·06
Madeira	Long kept in cask in the East Indies. Strongest	16·90	37·06
	Long kept in cask in the East Indies. Weakest.	14·09	30·86
Teneriffe (long in cask at Calcutta)		13 84	30·21
Cercial		15·45	33·65
Lisbon (dry)		16·14	34·71
Shiraz		12·95	28·30
Amontillado		12·63	27·60
Claret (a first growth of 1811)		7·72	16·95
Chateau-Latour (ditto 1825)		7·78	17·06
Rosan (second growth of 1825)		7·61	16·74
Ordinary Claret (Vin Ordinaire)		8·99	18·96
Rivesaltes		9·31	22·35
Malmsley		12·86	28·17
Rüdesheimer.	1st quality	8·40	18·44
,,	Inferior	6·90	15·19
Hambacher.	Superior quality	7·35	16·15

According to WAGNER, red French wines contain 9 to 14 per cent. by volume of alcohol. Burgundy, 9, 10, and 11 per cent. Bordeaux, 10, 11, and 12 per cent. Other French wines contain 8 to 10 per cent.; the wines of the Palatinate, 7 to 9·5 per cent.: Hungarian wines, 9 to 11 per cent. Champagne contains 9 to 12 per cent.; Xeres, 17 per cent.; Madeira, 17 to 23·7 per cent.

In addition to ethylic alcohol and water, which, as shown

in the previous table, vary largely in the proportions in which they are present in different kinds of wine, most wines contain the following substances:*—

Propylic, butylic, caprylic and caproic alcohols.	Carbonic acid.
Acetic and œnanthic ether.	Ordinary and levo-tartaric and racemic acids.
Grape sugar (dextrose and levulose).	Citric acid.
Glycerin.	Malic acid.
Gums.	Tannic acid.
Pectin.	Acetic acid.
Colouring and fatty substances.	Lactic acid.
Protein bodies.	Succinic acid.
	Organic and inorganic salts.

Of these, the propylic and butylic, caprylic, and caproic alcohols, the ethers, the glycerin, the carbonic, acetic, lactic, and succinic acids are produced during fermentation, the remaining substances being original constituents of the grape juice, which also contains bitartrate of potash;† but this being insoluble in weak spirit, is thrown down or deposited as the conversion of sugar into alcohol proceeds. In its crude condition, it is known as "argol," and is the source of cream of tartar and tartaric acid. As a result of its formation in the grape, a considerable amount of free acid is removed from the fruit. This is why wine

* Trimethylamine has also been found in wine.

† Beeswing, the second or pseudo-crust so much admired in port, and a few other wines, consists of minute glittering and floating particles of tartar or bitartrate of potash, purer and more free from astringent matter than that deposited in the first crust. It forms only in those wines which have been kept for some time after the first or true crust has formed.

made from grapes is so much superior, and keeps so much better than that manufactured from fruits that abound instead in citric and malic acids. These latter require the addition of large quantities of sugar to disguise their acidity, a proceeding which frequently gives rise in them to a second fermentation, and often to the consequent formation of acetic acid. The acetic ether in wine is produced by the mutual reaction of acetic acid and ethylic alcohol. NEUBAUER, dissenting from DUPRÉ and THUDICHUM, says the œnanthic ether is the constituent to which wines owe their bouquet. He regards this ether as a combination of various substances of which caprylic and caproic acid ethers are the most important. Their formation is believed to take place partly during and partly after fermentation. The rest of the non-volatile constituents, such as the sugar, the gum, the protein bodies, colouring matter, inorganic salts, &c., which remain behind when a wine is evaporated to dryness, constitute, with a certain quantity of substance the composition of which has not been defined, the "extractive matter."

The amount of extractive matter in wines varies as greatly as from 1 to 20 per cent. This difference occurs even in wines of a similar character, and from the same district. Thus in Rhine wines it ranges from 10·6 to 4·2 per cent., in the Palatinate wines from 10·7 to 1·9 per cent., in Bohemian wines, the mean is 2·26, in the wines of Austria, 2·64, and in those of Hungary 2·62 per cent. It is highest in sweet wines. In many adulterated wines, as the extractive matter is either very small or sometimes altogether absent, it has been proposed to employ the estimation of its amount in a wine, as a test of its genuineness or the reverse.

Light wines owe their colour, varying from pale yellow to brown, possibly to oxidized extractive matter, or to

the cask. The colour of red wine is due to the action of its free tartaric acid on a blue substance residing in the skin of the grape. This body, which is known to wine makers as "wine-blue," and which bears a great resemblance to litmus, in turning red when acted upon by acids, was named *œnocyan*, or *œnocyamin*, by MULDER or MAUMENÉ. It is insoluble in water, alcohol, ether, olive oil, and oil of turpentine, but is dissolved by alcohol containing small quantities of tartaric or acetic acid. Glycerin was found to be a normal constituent of wine by PASTEUR in 1859. As the wine matures, the glycerin disappears. In Austrian wines, POHL found 2·6 per cent. of glycerin. In some wines it reaches 3 per cent., but in most it seldom exceeds 1 per cent. In old wines it exists only in very small quantity. FAURE states that another normal constituent of wine is a gum, to which is given the name *œnanthin*.

The ash of wine, as might be expected, contains the same fixed constituents as that of the grape juice, and in both, the potash and phosphoric acid largely predominate.*

* We append some analyses of wine-ash. The first four were made by CRASSO, the fifth by BOUSSINGAULT.

	1	2	3	4	5
Ash (per cent.)	0·26	0·34	0·41	0·29	0·18
Potash	65·5	63·9	71·3	62·0	45·0
Soda	0·3	0·4	1·2	2·6	—
Lime	5·2	3·4	3·4	5·1	4·9
Magnesia	3·3	4·7	4·0	4·0	9·2
Oxide of iron	0·7	0·4	0·1	0·4	—
Oxide of manganese	0·8	0·7	0·1	0·3	—
Phosphoric acid	15·4	16·6	14·1	17·0	22·1
Sulphuric acid	5·2	5·5	3·6	4·9	5·1
Silica	2·0	2·1	1·2	2·2	0·3
Chloride of potassium	1·5	2·1	1·0	1.5	—
Carbonic acid	—	—	—	—	13·3
	100·0	100·0	100·0	100·0	100·0

As the excellence and character of a wine depend, in addition to its peculiar bouquet, upon the relative proportions of alcohol, free acid, and water, and as these are approximately constant in all wines of good quality, it is essential that the grape juice should not only contain such an amount of sugar as when fermented will yield the requisite quantity of alcohol (but since the goodness of the wine is inversely as its content of free acid), that the latter should not exceed a certain limit. The taste of a wine, however, is frequently a fallacious test as to the quantity of free acid in it. Of two wines, one containing more free acid than the other, the latter may be less sour to the palate, provided it contains a larger proportion of sugar, glycerin, or alcohol than the former.

Apart from the consideration, whether the acid of the grape eventually becomes transformed into sugar or not, the fact remains that in sunless and wet years, when the fruit has not sufficiently ripened, there is a deficiency of sugar, and an excess of acid. FRESENIUS states that the proportions are in—

Grapes grown in a very inferior year as	1	of acid to	12	of sugar
,, ,, better year	1	,,	16	,,
,, ,, good ,,	1	,,	24	,,

According to the same authority, when the proportion reaches one of acid to ten of sugar, the grape is unsuited for making wine.

To get over the difficulty of dealing with a must that contains too low a proportion of sugar, and too high a one of acid, two methods are adopted by the wine maker. The first, which was proposed by CHAPTAL, in an essay on the cultivation of the grape, published so long ago as 1800, consists in adding raw sugar to the must, in quantity sufficient to yield the amount of alcohol in which the wine would be otherwise deficient. CHAPTAL calculated

that two parts of sugar would give one part of alcohol. If, therefore, the grape juice should be found upon analysis capable of producing a wine with only 8 per cent. of alcohol, instead of its normal amount, say, of 16 per cent. after fermentation for every hundred parts of wine to be manufactured, 16 parts of sugar would have to be added. When the amount of free acid in the must exceeds 6 parts in 1,000, powdered marble is added, in the proportion of 50 parts of marble for every 60 parts of acid in excess. This method is inapplicable if the acid exists as acetic.

By Gall's method, when the free acid in the must exceeds 0·6 per cent., the juice is diluted with water to that strength. In this case the percentage of sugar will also have been reduced. Gall believed a normal must should have the following composition :—

Sugar	24·0 per cent.
Free Acid	0·6 „
Water	75·4 „

100 parts by weight of such a must would therefore contain 24 parts of sugar, 0·6 parts of free acid, and 75·4 parts of water. If by examination a sample of grape juice should be found to contain, say, 16·7 per cent. of sugar, and 0·8 per cent of free acid, to bring it up to Gall's standard, it would be necessary to add to every 1,000 lbs. of such juice, 153 lbs. of sugar and 180 lbs. of water.

Grape sugar made from starch, and dilute sulphuric acid, is usually employed for this purpose, but such sugar has the objection of containing large quantities of dextrin, the presence of which injures the keeping power of the resulting wine. The wine produced by Gall's plan is said to be very pleasant, and not devoid of natural bouquet. Sometimes the wine maker adds a flavouring material to it. The process seems best adapted for those musts which are poor in sugar, but contain an excess of free acid. The

removal of this may also be satisfactorily accomplished by the use of neutral tartrate of potash (see page 257). Amongst other methods practised for increasing the alcoholic content of wine, is that of submitting it to a temperature at or below freezing, whereby a considerable quantity of its water becomes congealed, and may be separated along with some tartar, and colouring and albuminous matters, which are precipitated by the cold. Owing to the removal of these last from the wine, it is not so liable to undergo a second fermentation, whilst the abstraction of part of its water, of course, makes it richer in alcohol.

Gypsum is also frequently added to wines for the purpose of withdrawing some of their water, and therefore of increasing their strength. This it does, but only to a trifling extent. At the same time, it should be remembered that its addition to wine gives rise to the formation of soluble sulphate of potash, a bitter and active purgative, and wholly or partly removes the tartaric acid and the phosphates. Dupré and Thudichum have shown by experiment that this practice of "plastering," as it is called, also reduces the yield of the liquid, as a considerable part of the wine mechanically combines with the gypsum and is lost.

Another reprehensible practice, is the addition to the wine of brandy or of spirits of wine. To assist in the preservation of such wines during exportation, the French Government allowed the addition of five litres of brandy to every thousand litres of wine, provided the total amount of alcohol after such addition did not reach more than 21 per cent. Owing, however, to this limit being frequently exceeded by unprincipled wine dealers, the authorities have been compelled to restrict the permission of making the addition of brandy to the departments of the Pyrénées d'Orientale, Aude, Hérault, Garde, Bouche du Rhône, and Var. In Spain and Portugal also, it is a frequent prac-

tice to add alcohol to sherry and port, although it has been shown that they need no such addition to prepare them for export.

In France and Germany, large quantities of wine,—if an alcoholic beverage, in the manufacture of which no grape-juice has been employed, can be called "wine"—are made by a process invented by PETIOT in 1852. This process is as follows:—The juice is pressed from the grapes, removed, and measured, and its content of sugar ascertained by the usual methods. A solution of sugar in cold water, equal in strength to that found in the must, and also corresponding to this latter in bulk, is then poured upon the marc. If the artificial must has been found deficient in free acid, this must be made up to the normal amount by the addition of tartaric acid. Fermentation very quickly ensues, and is completed in two or three days. The same marc is treated in a similar manner with a fresh quantity of sugar solution, and sometimes undergoes as many as three or four separate macerations, each successive infusion occupying a rather longer time. The natural grape-juice first obtained generally undergoes a separate fermentation, the wine being generally kept distinct.

If white grapes are used in the above process, the more luscious they are, the better wine they produce; with black or purple fruit over-ripeness is found to be objectionable, because it causes the wine to age too soon.

Wine obtained by PETIOT's method is stated to be rich in alcohol, and excellent in odour and taste. Wine so prepared is said to possess a finer bouquet than the natural wine, and to be superior to this in keeping qualities. The wines are rather darker in colour than those made from natural must.

Maladies of Wines.—After standing in the casks, many wines become viscid or ropy. Those which are deficient in tannin are especially liable to run into this condition, hence

the practice of adding to the must of white wines, the stalks of the grape, which contain tannin.

VISCIDITY OR ROPINESS has been attributed to the presence in the wine of a vegetable albuminous ferment, which converts the glucose into mannite and mucus. To wine so affected, François suggests the addition of tannic acid in the proportion of ½ oz. of the acid to 50 gallons of wine. The tannic acid being thoroughly mixed with the wine, the whole must be kept perfectly quiescent for a few days, after which the acid having combined with and precipitated the nitrogenous body, the wine may be bottled. Oak bark, gall-nuts, and wood shavings are sometimes used for the same purpose. Other but more objectionable agents, are gypsum, alumina, and alum. The so-called "fining powder" usually consists of one or other of the above substances.

Wine, and more particularly that which has aged, or has been kept at too high a temperature, occasionally acquires a bitter taste. The origin of this bitter taste, which occasions what is known as "the BITTERING of wine," has been attributed to the action of a peculiar vegetable ferment upon some of the constituents of the wine. One chemist* believes the bitter substance to be "brown aldehyd resin." The remedies that have been proposed for correcting it are: fining by isinglass, carbonate of lime, and slaked lime. MAUMENÉ advises the addition of the latter to bittered wine, in the proportion of 4 to 7½ grains to 2¼ pints of wine.

An opposite, but less objectionable quality of some wines is OVER-SWEETNESS. In those years when the vintage is late, and the temperature correspondingly low, the fermentation is not active enough to convert all the sugar into alcohol. For the removal of the excess of sugar from a wine, no remedy beyond that of permitting its gradual ageing or

* Dr. R. Wagner.

maturation has hitherto been suggested. This process always occupies months, and in some cases years.

MOULD OR FUNGUS is very frequently produced by keeping the wine in too warm a cellar, or in a cask not filled to the bung-hole, or else in one from which the bung has been left out. As it forms mostly on weak wines, its presence may be referred to a deficiency of alcohol.

The best method for its removal is either burning sulphur in a partially filled cask, or drawing off the wine into a fresh cask, in which sulphur has been previously burnt. It is advisable that wines so treated should be drunk as soon as possible.

Wine sometimes has an unpleasant musty taste, which it has acquired from being put into a dirty cask, or into one that has been unused for some time. This bad flavour, which is known as "CASKINESS," may generally be removed by vigorously agitating the wine for some time with a little sweet olive or almond oil. The cause of the bad taste is the presence of an essential oil, which the fixed oil combines with and carries to the surface, whence it may be skimmed off, or the wine lying under it may be drawn off. A little coarsely powdered and freshly burnt charcoal, or some slices of bread toasted until they become black, or a little bruised mustard-seed, sometimes effects the removal of the objectionable taste.

The best method of treating wines that are sour from an excess of acid in the grape, the result of a wet or ungenial season, has been previously described under the method of CHAPTAL and GALE. The SOURNESS of wine, due to another cause—viz., the presence of acetic acid, may be owing to its not being sufficiently strong in alcohol, to an excess in the must of albuminous matter, or to being kept at too high a temperature. Wines of this description will be particularly liable to run into the acetous fermentation, if unnecessarily exposed to the air.

It is, therefore, of great importance that the casks containing them should be filled to the bunghole, and carefully corked. Sometimes the acidity may be arrested by sulphuration. Carbonic acid, passed into the wine, has been proposed for destroying the *mycodermi aceti*, which are the originators of the vinegar. Racking the wine into fresh and new casks sometimes acts as a preventive. Tartaric acid has sometimes been found serviceable, as it forms acetic ether with the injurious acetic acid.* The salts of potash, soda, or lime, are unsuited for neutralizing agents, when the sourness is owing to acetic acid, as they form bodies which give a disagreeable taste to the wine. When the wine is very sour, it is only fit to be made into vinegar. The addition of sugar to wine that does not contain much acetic acid sometimes successfully disguises it.

Some wines DECAY. Such wines turn turbid and thick, acquire an astringent taste, and eventually become sour. The change is accompanied with the destruction of their sugar and glycerin, the conversion of their bitartrate of potash into carbonate, and the evolution of carbonic acid. Sometimes a small quantity of ether added at the commencement of the decomposition serves to put an end to it.

PASTEUR asserts that many of the previous ailments of wine, such as its bitterness, souring, decay, viscidity or ropiness, are caused by the presence of low vegetable cells or organisms, the growth and development of which are promoted by slight elevations of temperature or exposure to the air. For the destruction of these organisms, when the wine is bottled, he adopts the following plan:—The bottles being filled up to the cork and closed, are placed in an apartment heated to 113° Fahr. (45° C.), or 212° Fahr. (100° C.). The corks must be so arranged that when the wine becomes expanded by the heat, they shall

* Wagner.

only be forced up *into* the neck of the bottle, but not out of it. By this means air is prevented getting into the bottles. After remaining in the heated chamber for one or two hours, the bottles are removed, and being allowed to cool gradually, the corks are driven in and properly secured. OPPERT'S is a modification of the above method, and consists in heating the wine in a water-bath to a temperature of 158° Fahr. (70° C.). The wine is contained in bottles or receptacles hermetically sealed.

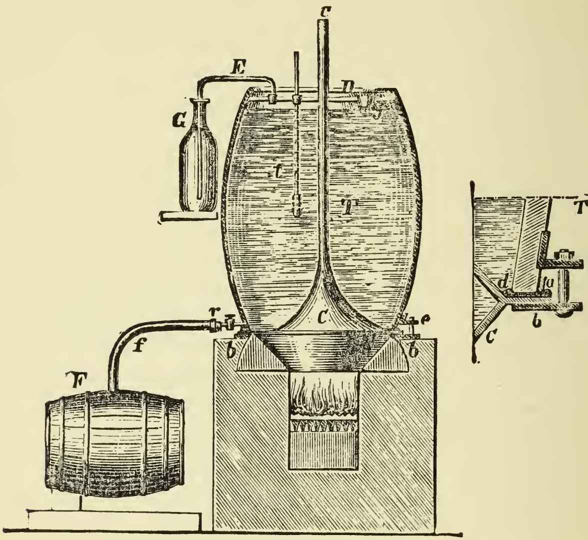
Wine which has been artificially aged or matured by the above processes, is said to have undergone the operation of "Pasteuring" or "Pasteurization." For the Pasteurization of wine that is intended to be placed in casks, a particular apparatus is required. The drawing on the next page represents a contrivance devised for this purpose by ROSSIGNOL. To the bottom of a metal cask T, is fixed a tinned copper pan C, with a trumpet-shaped cover, ending in the open tube *c*, above the top of the vessel T. *t* is a thermometer. Water is poured into the pan C and the tube *c*, until this latter is three-parts full. The wine is then run into the cask T, and the water in the copper pan C heated by the furnace as shown in the drawing.

When the thermometer *t* registers 140° Fahr. (60° C.) by means of the tap *r*, the wine is drawn off through the pipe *f* into the cask F. The cask is then re-filled with fresh wine, and the operation repeated, it being only necessary to occasionally wash out the metal cask C with water. This removes the wine lees that, in course of time, if suffered to remain, would communicate a disagreeable taste to the Pasteured wine.

The smaller figure represents the method by which the cask and pan C are fastened together. A tinned copper ring *a* surrounds the cask T, and beds with the walls of this vessel into the india-rubber band *d*, into which it is pressed

by the tightening of the screw-bolts *e*, binding the ring of angle iron and the lower iron ring *b* together. By this arrangement a perfect joint is obtained. As it is important

FIG. 17.



during the operation that no air should be allowed to come into contact with the wine, and that the cask T should in the first place be quite full, the overflow of the liquid which takes place when it is heated is carried off by a glass or tin tube E into the bottle G. As it is of the utmost importance that the casks into which the heated wine is drawn off should be quite full, to save the labour of filling up the space caused by the cooling of the wine, the hot wine is sucked into casks connected with each other by bent tubes. By this means the wine is conveyed from cask to cask as their contents cool.

All the above processes are said to answer admirably, and it is stated the wine is not only greatly improved in colour

and bouquet, but bears exportation well whether in casks or bottles, and will keep for years. When the casks containing it are stored, they may be placed in cellars, having an ordinary temperature.

Utilization of Grape Residues.—The marc or residue left after the expression of the juice from the grapes is used for a variety of purposes. 1. As frequently affording, when subjected to a second pressing, a not inconsiderable quantity of grape juice, the lees are the source of an inferior description of wine.* 2. A common kind of brandy is made by distilling the liquid obtained by fermenting the grape skins. 3. If the tolerably concentrated aqueous liquid, left after the distillation, be separated by a sieve from the skins, it will deposit crude tartar, and if the skins are burnt they will yield carbonate of potash. 4. Another kind of brandy is distilled from wine lees, the last portions of the distillate consisting of an oil of most pleasant flavour. This, which is œnanthic ether, is known commercially as "wine-oil," "cognac oil," "huile de marc." 5. In wine-making districts wine lees are used as food for horses, mules, or donkeys. 6. Or as manure for the grape. 7. The black pigment of the artist, known as "vine black," is procured by calcining the grape stalks and seeds. 8. By bringing sheets of copper into contact with the marc, and allowing the acetous fermentation to be set up in it, verdigris or basic acetate of copper is produced. 9. Tannic acid is obtained in large quantities from grape seeds. 10. By treating the seeds with benzol or carbon bisulphide, a large amount of fatty oil is obtained. 11. The lees are sometimes used in vinegar-making, as by adding them under suitable conditions to saccharine or alcoholic liquids, they give rise to the acetous fermentation. 12. Cream of tartar and tartaric acid are

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* *See* Petiot's process, page 237.

chiefly procured from the crude tartar or argol found adhering to the sides of wine casks. The crude tartar contains besides bitartrate of potash, tartrate of lime, yeast, and colouring matter.

How to Test Must and Wine.—1. *Richness in Alcohol.* This may be found in wine by any of the methods noticed under ALCOHOLOMETRY.

2. *Acidity.*—The acidity in wine can be ascertained by following any of the processes employed in ACIDIMETRY. If the wine is coloured, distilled water must be added in quantity sufficient to give a liquid, in which the reaction, when it takes place, can be distinctly seen. To estimate the amount of acid in must, PAYEN adopts the following mode of procedure:—

He prepares a solution of lime of such a strength that 27·5 c.c. equal 0·06125 grms. of sulphuric acid; 0·075 grms. of acetic acid; 0·09375 grms. of tartaric acid; and 0·0235 grms. of bitartrate of potash.

Ten c.c. of clear must are put into a beaker without litmus, and the lime water is added from a burette until by the change in the colour the neutral point is attained. The reading of the burette being then taken, the percentage of acid is calculated.

When the must is not clear, lime water is added, insufficient to saturate the acid; the liquid is then filtered, and more lime water is added, until alteration of colour takes place.

Sugar.—The determination of the amount of sugar in must by means of the hydrometer can only be approximate, as the must, in addition to saccharine matter, contains other compounds, the presence of which affects the specific gravity of the liquid. In the following table allowance is made for these non-saccharine compounds, and the specific gravity therefore indicates the corresponding percentage of sugar:—

Corrected Specific Gravity.	Per cent. of Sugar.
1·010	3
1·016	4
1·020	5
1·024	6
1·028	7
1·032	8
1·036	9
1·040	10
1·042	11
1·044	12
1·048	13
1·053	14
1·0572	15
1·0614	16
1·0657	17
1·0744	18
1·0788	19
1·0832	20
1·0877	21
1·0922	22
1·0967	23
1·013	24
1·059	25
1·1106	26
1·1153	27
1·1200	28
1·1247	29
1·1295	30

The determination of the sugar by means of an alkaline copper solution, such as FEHLING's, is not only a troublesome but unreliable method, the copper being reduced by tannin and other bodies present in the wine, as well as by glucose. The necessity of previously removing the colour from the wine also complicates the process.

Extractive Matter.—This may be ascertained by carefully evaporating a weighed quantity of the wine or must in a platinum dish, to dryness, and weighing the residue.

Ash.—Twenty cubic centimetres of the wine are evapo-

rated over a water-bath, in a platinum or porcelain dish to dryness, and the residue afterwards kept for a short time in an air-bath at a temperature of 250° Fahr. (121° C.). It is then heated to dull redness in a crucible over a gas-flame, until only a white or grey ash remains. When this has been cooled under a desiccator and weighed, the amount multiplied by five gives the percentage of ash in the sample of wine under examination.

Adulteration of Wines.—The most frequent species of fraud in the wine trade is the mixing of wines of inferior quality with those of a superior grade. In many cases the commoner kinds of foreign wines are flavoured and substituted for the more expensive ones.

The wines of Médoc, or those vended under that name, before being exported or sold, are so extensively blended with inferior and stronger French wines as, according to one writer, to be increased to six times their original bulk. They are also largely fortified with alcohol, particularly for the English market. Unfortunately for the detection of the first form of adulteration, there are no more definite tests than the taste and smell; on this point, therefore, the experienced wine-taster's opinion is of greater value than the chemist's analysis. Formerly, it was a common practice of ignorant wine-dealers to add a little litharge or acetate of lead to their inferior wines to correct their acidity, but it is believed that this highly poisonous substance is now never employed in this country, salt of tartar or carbonate of potash being made to perform the same duty. The lead which is frequently detected in bottled wine, and which often causes serious indisposition, may be generally traced to shot being carelessly left in the bottles, and not to wilful fraud. Sherry is commonly coloured in Spain by the addition of must boiled down to one-fifth of its original volume; and in England, by burnt brown sugar, or spirit colouring. Amon-

tillado (a very nutty wine) is frequently added to sherries deficient in flavour. Various other ingredients, as the essential oil of almonds, bitter almonds in substance, cherry-laurel leaves, cherry-laurel water, &c., are also employed for a similar purpose.

In Portugal the juice of elderberries is very often added to port wine to increase its colour, and extract of rhatany for the double purpose of improving its colour and imparting an astringent taste.

To make port wine form a crust on the inside of the bottles, some powdered catechu or finely powdered cream of tartar is added to each bottle, by unprincipled vendors, before corking it, after which the whole is well agitated. Sometimes the crust is manufactured and made to adhere to the sides of the bottle before putting the wine into it, by employing a hot saturated solution of red tartar, thickened with gum and some powdered tartar.

In England beetroot, Brazil wood, the juices of elderberries and bilberries, the pressed cake of elder wine, extract of logwood, &c., are frequently added to port to deepen its colour; and oak sawdust, kino, and alum, to increase its astringency. But the most common adulterant of port wine, both in Portugal and this country, is "jerupiga," or "geropiga," a compound of elder juice, brown sugar, grape juice, and crude Portuguese brandy. A fawn-yellow and golden-sherry yellow are given by means of tincture or infusion of saffron, turmeric or safflower, followed by a little spirit colouring, to prevent the colour being too bright. All shades of amber and fawn, to deep brown and brandy colour, are given by burnt sugar.

In addition to the list of spurious colouring matters given above, the following, according to PAYEN, are also had recourse to by the makers of red wines, in France:—Red poppies, privet berries, dwarf elderberries, mallow flowers,

and fuchsine or aniline red. The mode of detecting most of these substances is given further on, under ADULTERATION TESTS.

The colour of wine is precipitated by age and by exposure to the light. It is also artificially removed by the action of skimmed milk, lime water, milk of lime, and freshly burnt charcoal. Some dealers avail themselves of this property for the purpose of whitening wines that have acquired a brown colour from the cask, or which are the more esteemed if pale; and also for turning pricked red or dark-coloured wines into white wines, in which a small degree of acidity is not so much perceived. In this way brown sherry is commonly converted into pale or gold-coloured sherry.

Various ingredients are often added to inferior wines, to give them the flavour of more expensive ones, and to British wines, to make them resemble those which are imported. Substances are also added with the object of communicating the aroma of the genuine wines. Among the first class are bitter almonds, almond cake, the essential oil of almonds, or, preferably, its alcoholic solution. These are used to impart a sherry or nutty taste to weak-flavoured wines, such as poor sherry, malt, raisin, parsnip, and other similar British wines. Rhatany, kino, oak sawdust and bark, alum, &c., are employed to give astringency, and the tincture of the seeds of raisin, to impart a port-wine flavour. Among the substances employed to impart the bouquet of the finer wines, may be mentioned—orris root, eau de fleurs d'oranges, neroli, essence de petit grain, ambergris, vanilla, violet petals, essence of cedrat, sweet briar, clary, elder-flowers, quinces, and cherry-laurel water. A grain or two of ambergris, well rubbed down with sugar, and added to a hogshead of claret, gives it a flavour and bouquet much esteemed by connoisseurs. See also EXAMPLES OF BRITISH IMITATIONS OF FOREIGN WINES, p. 264.

Adulteration Tests.—1. LEAD.—The presence of lead or litharge in wine may be readily detected either:—

a. By sulphureted hydrogen, or a solution of any alkaline sulphydrate, which will, in that case, produce a black precipitate. Or by:—

b. Quicklime, 1 oz.; flowers of sulphur, 1½ oz.; mix, and heat them in a covered crucible for five or six minutes; put 2 drs. of the product and an equal weight of tartaric acid (separately powdered), into a stoppered bottle, with a pint of water, and shake them well; let the liquid settle, pour off the clear portion, and add of tartaric acid 1½ dr.

c. (Dr. Paris's.) From sulphide of calcium and cream of tartar, of each (in powder), ½ oz.; hot water, 1 pint; agitate, &c., as before; decant the cold clear liquid into 1 oz. phials, and add 20 drops of hydrochloric acid to each of them.

The above tests will throw down the least quantity of lead from wines, in the form of the black sulphide. As iron might be accidentally contained in the wine, the hydrochloric acid is added to the last test, to prevent the precipitation of that metal.

2. POTASSA or SODA intentionally added.—A portion of the wine is evaporated nearly to dryness, and then agitated with rectified spirit; the filtered tincture, holding in solution acetate of potassa or soda, is then divided into two portions, one of which is tested for acetic acid, and the other for the alkali.

3. ALUM.—A portion of the wine is evaporated to dryness, and ignited; the residuum is then treated with a small quantity of hydrochloric acid, the mixture evaporated to dryness, again treated with dilute hydrochloric acid, and tested with liquor of potassa. If a white bulky precipitate forms, which is soluble in an excess of caustic potassa, and which is re-precipitated by a solution of sal ammoniac, the sample examined contains alum.

4. OIL OF VITRIOL.—*a.* A drop or two of the suspected

wine may be poured upon a piece of paper, which must then be dried before the fire. Pure wine at most only stains the paper, but a sample containing sulphuric acid causes it to become charred and rotten. The effect is more marked on paper which has been previously smeared with starch paste.

b. According to M. Lassaigne, pure red wine leaves, by spontaneous evaporation, a violet or purple stain on paper; whilst that to which sulphuric acid has been added, even in quantity, only equal to $\frac{1}{2000}$ to $\frac{1}{3000}$th part, leaves a pink stain in drying.

5. Spurious Colouring Matter.

a. (Payen)* :—

				Precipitates.
Pure red wine gives with acetate of lead			. .	bluish grey.
Red poppy	,,	,,	,, . .	dirty grey.
Elderberry	,,	,,	,, . .	dirty green.
Bilberry	,,	,,	,, . .	greyish green.
Privet berry	,,	,,	,, . .	green.
Dwarf elder	,,	,,	,, . .	bluish grey to violet in the fresh berries, and fine green in the fermented extract.
Mallow flower	,,	,,	,, . .	dark green.
Logwood	,,	,,	,, . .	feeble dark blue.
Brazil wood	,,	,,	,, . .	wine red.
Pure red wine	gives with alum and carbonate of ammonia . . .			dirty green.
Red poppy	,,	,,	,, . .	slate grey.
Elderberry	,,	,,	,, . .	bluish grey.
Bilberry	,,	,,	,, . .	bright violet.
Privet berry	,,	,,	,, . .	,, green.
Dwarf elderberry	,,	,,	,, . .	,, violet.
Mallow flower	,,	,,	,, . .	bluish violet.
Logwood	,,	,,	,, . .	dark violet.
Brazil wood	,,	,,	,, . .	carmine red.

* Payen's "Industrial Chemistry," edited by Dr. Paul. Longman & Co.

b. Pure red wine is perfectly decoloured by agitation with recently prepared hydrate of lime.

c. Dissolve a piece of caustic potash in a small quantity of the liquid to be examined. If no deposit be formed, and the wine assumes a greenish shade, there is no artificial coloration. A violet-coloured deposit indicates the presence of elderberries or mulberries; a red one, that of beetroot or Brazil wood; red violet, that of logwood. If the deposit is blue violet, privet berries have been employed; and if pale violet, the coloration is due to litmus.

d. For the detection of the principal colouring matters employed in the sophistication of wines, M. Chancel proceeds as follows:—He takes 10 c.c. of wine, and adds 3 c.c. of a dilute solution of subacetate of lead, allowing the mixture to subside for a few minutes to make sure that the precipitation is complete. Should this not be the case a slight excess of the re-agent is added.

After stirring and heating for a few moments the precipitate is thrown on to a small filter, the filtrate collected in a test-tube, and the precipitate washed three or four times in hot water. If the filtrate is coloured, magenta is present, and may be sought for by the aid of the spectroscope. But if the wine contains a mere trace of this colour, it is retained in the precipitate, and is sought for in the manner directed below. To discover the colouring matter which may be contained in the plumbic precipitate, it is treated upon the filter with a few c.c. of a solution of carbonate of potassa (2 parts of the dry salt to 100 of water), taking care to repass *the same solution* several times through the precipitate. Any magenta present is thus extracted, along with carminamic (ammoniacal cochineal) and sulphindigotic acid. The colouring matters of logwood and of alkanet remain undissolved.

With a genuine wine the alkaline liquid takes a very faint yellow or greenish-yellow tint. For the detection of magenta

the filtrate is mixed with a few drops of acetic acid, and it is then shaken up with amylic alcohol. The magenta dissolves in this alcohol with a fine rose tint, and its presence is proved by spectroscopic examination. Carminamic and sulphindigotic acids remain in the aqueous solution, and are decanted off. A couple of drops of sulphuric acid are added, and the mixture is again shaken up with amylic alcohol, which now dissolves the ammoniacal cochineal. It may be detected by the spectroscope. The sulphindigotic acid remains undissolved in the amylic alcohol, and may be found in the blue aqueous residual liquor by means of the spectroscope. Logwood is most conveniently sought for in a fresh portion of the wine by digestion with a little precipitated carbonate of lime, adding a few drops of lime-water, and filtering. In a natural wine the filtrate has a faint greenish-yellow colour, but if logwood is present it takes a fine red shade, and the absorption bands of logwood may be detected with the spectroscope. On treating the lead precipitate above mentioned with an alkaline sulphide, washing with boiling-water, and then treating with alcohol, the colouring matter of alkanet, if present, is dissolved, and may be detected by spectroscopic examination.*

e. (DR. DUPRÉ.)—The colouring matter of pure red wine does not pass through the dialyser. The dialysate from pure wine is therefore colourless, or shows but a slight purplish coloration, such as water would assume on the addition of a small quantity of the wine. A yellowish or brownish-yellow dialysate indicates an adulteration with logwood, Brazil wood, or cochineal, the colouring matters of which may be identified by the chemical and optical tests employed for this purpose. The ammoniacal solution of the colouring

* *Comptes Rendus*, February 19th, 1877. (*Chemical News*, xxxv. p. 106.)

matter of cochineal yields three well-marked absorption bands.

f. For the detection in wine of fuchsine only, the following methods are given by M. E. Jacquemin:—1. A small quantity of gun-cotton is heated for a few minutes in from 10 to 20 c.c. of the wine, and then washed with water. The nature of the coloration (if any) imparted to the cotton is now identified by means of solution of ammonia, which decolorises rosaniline, but turns archil violet. 2. 100 c.c. of the wine are boiled to expel the alcohol, and then boiled for some time with white Berlin wool, previously moistened with water. The colour imparted to the wool by fuchsine is retained after washing, and may be distinguished from archil by ammonia. 3. 100 to 200 c.c. of the wine are boiled to expel the alcohol, then allowed to cool, mixed with ammonia in excess, and shaken with ether. By immersing white wool in the ethereal solution, and evaporating the latter, the wool acquires the characteristic colour of fuchsine.

6. Artificial Flavouring.—This, as already stated, can only be detected by a discriminating and sensitive palate.

7. Artificial Bouquet.—The substances added for this purpose may sometimes be detected by a comparison of the sample with another of known purity.

MANAGEMENT OF WINE.

The remarks arranged under this heading are more particularly intended for the use of the dealer, the publican, and the private individual; as those which precede it, are for the wine-maker; matters common to each class will however be found in both sections of the present article.

Age.—The sparkling wines are in their prime in from eighteen to thirty months after the vintage. Thin wines, of inferior growths, should be drunk within twelve or fifteen

months, and be preserved in a very cool cellar. Sound, well-fermented, full-bodied still wines are improved by age, within reasonable limits, provided they be well preserved from the air, and stored in a cool place having a pretty uniform temperature.

Bottling.—The secret of bottling wine with success consists in the exercise of care and cleanliness. The bottles should be sound, clean, and dry, and free from the least mustiness or other odour. The corks should be of the best quality, and immediately before being placed in the bottles should be compressed by means of a cork-squeezer, or of one of the numerous machines made for this purpose. For superior or very delicate wines, the corks are sometimes prepared by placing them in a copper or tub, covering them with weights to keep them down, and then pouring over them boiling water holding a little pearl-ash in solution. In this liquid they are allowed to remain for twenty-four hours, when they are well stirred about in the liquid, drained, and re-immersed for a second twenty-four hours in hot water, after which they are well washed and soaked in several successive portions of clean and warm rain-water, drained, dried out of contact with dust, put into paper bags, and hung up in a dry place for use. Many wine-merchants, however, disapprove of this course, and merely dip the corks in clean cold water before inserting them in the bottles. The wine should be clear and brilliant, and if it be not so, it must undergo the process of fining* before being bottled. The bottles, corks, and wine, being ready, a fine

* In fining clarets, French white wines, German wines, and, in short, all light wines, after the addition of the fining materials, and the insertion of the bung, the cask should be turned lightly round, so that the contained wine shall entirely surround the bunghole. By this contrivance the wine acts as a trap, and excludes the outer air.

clear day should be preferably chosen for the bottling, and the utmost cleanliness and care should be exercised during the process. Great caution should also be observed to avoid shaking the cask, so as not to disturb the bottoms. The remaining portion that cannot be drawn off clear should be passed through the "wine-bag," and, when bottled, should be set apart as inferior to the rest; or the lees are collected in a cask kept for the purpose, and the clear wine resulting from their subsidence is used for filling up casks about to be fined. The coopers, to prevent breakage and loss, place each bottle, before corking it, in a small bucket or boot having a bottom made of soft cork or leather, which is strapped on the knee of the bottler. The bottlers seldom break a bottle though they "flog in" the corks very hard. The bucket or boot is now very largely supplanted by GERVAISE'S corking machine, an apparatus which first submits the cork to great pressure, and then immediately afterwards drives it firmly into the neck of the bottle, in which, owing to its subsequent expansion, it fits very closely and perfectly. When the process of bottling is complete the bottles of wine are stored in a cool cellar on their sides, but on no account in an upright position. Sometimes they are placed in damp straw, or in sweet, dry sawdust, or sand.

Alcoholizing.—Alcohol is frequently added to weak or vapid wines, to increase their strength or to promote their preservation. In Portugal, one-third of alcohol is commonly added to port before shipping it for England, as without this addition it generally passes into the acetous fermentation during the voyage. A little alcohol is also usually added to sherry before it leaves Spain. The addition of alcohol to wine injures its proper flavour, and hence it is chiefly made to port, sherry, and other wines, whose flavour is so strong as not to be easily injured. Even when alcohol is added to wines of the latter description, they

require to be kept for some time to recover their natural flavour.

Cellaring.—A wine-cellar should be dry at bottom, and either covered with good hard gravel or be paved with flags. Its gratings or windows should open towards the north, and it should be sunk sufficiently below the surface to ensure an equable temperature. It should also be sufficiently removed from any public thoroughfare, so as not to suffer vibration from the passing of carriages. Should it not be in a position to maintain a regular temperature, arrangements should be made to apply artificial heat in winter, and proper ventilation in summer. The temperature should range from 55° to 65° Fahr. For Burgundies the former temperature is the more suitable; for ports, sherries, and strong wines, the latter temperature.

Decanting.—In decanting wine, care must be taken not to shake or disturb the crust when moving it about, or drawing the cork, particularly of port wine. Never decant wine without a wine-strainer, with some clean fine cambric in it, to prevent the crust and bits of cork going into the decanter. In decanting port wine, do not drain it too close; as there are generally two-thirds of a wine-glassful of thick dregs in each bottle, which ought to be rejected. In white wine there is not much deposit; but it should nevertheless be poured off very slowly, the bottle being raised gradually.

Detartarization.—Rhenish wines, even of the best growths, and in the finest condition, besides their tartar, contain a certain quantity of free tartaric acid, on the presence of which many of their distinctive properties depend. The excess of tartar is gradually deposited during the first years of the vatting, the sides of the vessels becoming more and more encrusted with it; but, owing to the continual addition of new wine and other causes, the liquid often

gains such an excess of free tartaric acid as to acquire the faculty of re-dissolving the deposited tartar, which thus again disappears after a certain period. The taste and flavour of the wine are thus exalted, but the excess of acid makes the wine less agreeable, and probably less wholesome.

Under these circumstances the best corrective is pure neutral tartrate of potash. When this salt, in concentrated solution is added to an acid wine, the free acid combines with the neutral salt, and separates from the liquid under the form of the sparingly soluble bitartrate of potash. "If to 100 parts of a wine which contains one part of free tartaric acid we add 1½ parts of neutral tartrate of potash, there will separate on repose at 70° to 75° Fahr., 2 parts of crystallized tartar; and the wine will then contain only ½ part of tartar dissolved, in which there are only ·2 part of the original free acid; ·8 part of the original free acid having been withdrawn from the wine."* This method is particularly applicable to recent must and to wines which contain little if any free acetic acid; when this last is present, so much acetate of potash is formed as occasionally to vitiate the taste of the liquid.

Fining.—Wine is clarified in a similar manner to beer. White wines are usually fined by isinglass. The quantity of isinglass varies with the quality and condition of the wine, and is regulated by the experience of the cellarman. Stout wines require a larger amount than thin ones. Even with stout ones it ought not to exceed ½ oz. to the hogshead. The Rhenish wines do not require more than ¼ oz., and the Hocks still less. The choicest Russian isinglass only should be employed. It should be dissolved in cold water, and thinned with wine. Red wines are generally fined with the whites of eggs, in the proportion of 15 to 20 to the pipe.

* Liebig's *Annalen.*

Sometimes, but rarely, hartshorn shavings, or pale sweet glue, is substituted for isinglass.

Flatness.—This is removed by the addition of a little new brisk wine of the same kind; or by rousing in 2 or 3 lbs. of honey; or by adding 5 or 6 lbs. of bruised sultana raisins, and 3 or 4 quarts of good brandy, per hogshead. By this treatment the wine will usually be recovered in about a fortnight, except in very cold weather. The process may be expedited, if a table-spoonful or two of yeast be added, and the cask removed to a warmer situation.

Insipidity.—See *Flatness.*

Maturation.—The natural maturation or "ripening" of wine and beer by age, depends upon the slow conversion of the sugar which escaped decomposition in the "gyle tun," or fermenting vessel, into alcohol. This conversion proceeds most perfectly in vessels which entirely exclude the air, as in the case of wine in bottles; as when air is present, and the temperature sufficiently high, it is accompanied by slow acetification. This is the case with wine in casks, the porosity of the wood allowing the very gradual permeation of the air. Hence the superiority of bottled, over draught wine, or that which has matured in wood. Good wine, or well-fermented beer, is vastly improved by age when properly preserved; but inferior liquor, or even superior liquor, when preserved in improper vessels or situations, becomes acidulous, from the conversion of its alcohol into vinegar. Tartness or acidity is consequently very generally, though wrongly, regarded by the ignorant as a sign of age in liquor. The peculiar change by which fermented liquors become mature or ripe by age is termed the "insensible fermentation." It is the alcoholic fermentation impeded by the presence of the already formed spirit in the liquor, and by the lowness of the temperature.

Ripening.—To promote the maturation or ripening of

wine, various plans are adopted by the growers and dealers. One of the safest ways of hastening this, especially for strong wines, is not to rack them until they have stood 15 or 18 months upon the lees; or, whether crude or racked, keeping them at a temperature ranging between 55° and 65° Fahr., in a cellar free from draughts and not too dry. Full or heavy sherries or ports, when bottled and treated in this manner, ripen very quickly in a temperate situation.

Racking.—Racking should be performed in cool weather, and preferably early in the spring. A clean siphon, well managed, answers better for this purpose than a cock or faucet. The bottoms, or thick portion, may be strained through a wine-bag, and added to some other inferior wine.

Ropiness, Viscidity; Graisse.—This arises from the wine containing too little tannin or astringent matter to precipitate the gluten, albumen, or other azotized substance, occasioning the malady, as explained at page 238. Such wine cannot be clarified in the ordinary way, because it is incapable of causing the coagulation or precipitation of the finings. The remedy is to supply the principle in which it is deficient. M. François, of Nantes, prescribes for this purpose the bruised berries of the mountain ash in the proportion of 1 lb. to the barrel. A little catechu, kino, or, better still, rhatany, or the bruised footstalks of the grape, may also be conveniently and advantageously used in the same way. For pale white wines, which are the ones chiefly attacked by the malady, nothing equals a little pure tannin or tannic acid dissolved in proof spirit *See also page* 238.

Second Fermentation; La-pousse.—Inordinate fermentation, either primary or secondary, in wine or any other fermented liquid, may be readily checked by sulphuration,

or by the addition of sulphur, mustard seed, or sulphite of lime. The latter must however be used with discretion.

Souring.—See page 239.

Sparkling, Creaming, and Briskness.—These properties are conveyed to wine by racking it into closed vessels before the fermentation is complete, and while there still remains a considerable portion of undecomposed sugar. Wine which has lost its briskness may be restored by adding to each bottle a few grains of white lump sugar or sugar candy. The bottles are afterwards inverted, by which means any sediment that forms falls into the necks, when the corks are partially withdrawn, and the sediment is immediately expelled by the elastic force of the compressed carbonic acid. If the wine remains muddy, a little solution of sugar and finings are added, and the bottles are again placed in a vertical position, and, after two or three months, the sediment is discharged as before.

Taste of Cask.—See page 239.

Wine, British.—The various processes in British wine-making are similar to those followed in the manufacture of foreign wines, and are conducted upon the same principles.

The fruit should be preferably gathered in fine weather, and not until mature, as evinced by its flavour ; for if it be employed whilst unripe, the resulting wine will be harsh, disagreeable, and unwholesome, and a larger quantity of sugar and spirit will be required to render it palatable. The common practice of employing unripe gooseberries for the manufacture of gooseberry wine arises from a total ignorance of the scientific principles of wine making. On the other hand, if ordinary British fruit be employed in too ripe a state, the wine is apt to be inferior, and deficient in the flavour of the fruit.

The fruit, being gathered, at once undergoes the operation of picking or garbling, for the purpose of removing the

stalks and unripe or damaged portions. It is next placed in a tub, and is well bruised, to facilitate the solvent action of the water, which is afterwards added. Raisins are commonly permitted to soak about twenty-four hours previously to bruising them, but they may be advantageously bruised or minced in the dry state. The bruised fruit or other vegetable product is then put into a vat or vessel with a guard placed over the taphole, to keep back the husks and seeds of the fruit when the must, or juice, is drawn off. The water is now added, and the whole is allowed to macerate for thirty to forty hours, more or less, during which time the magma is frequently roused up with a suitable wooden stirrer. The liquid portion is next drawn off, and the residuary pulp is placed in hair bags, and undergoes the operation of pressing, to expel the fluid which it contains. The sugar, tartar (in very fine powder or in solution), &c., are now added to the mixed liquors, and the whole is well stirred or rummaged up for some time. The temperature being suitable, the vinous fermentation soon commences, when the liquid, if necessary, is frequently skimmed, and well "roused" up, and, after three or four days of this treatment, it is run into casks, which should be quite filled, and left purging at the bunghole. In about a week the flavouring ingredients, in the state of coarse powder, are commonly added, and well stirred in; and in about another week, depending upon the state of the fermentation, and the attenuation of the must, the brandy or spirit is added, and the cask is filled up, and bunged closely down In four or five weeks more the cask is again filled up, and, after some weeks (the longer the better), it is "pegged" or "spiled," to ascertain if it be fine or transparent; if so, it undergoes the operation of racking; but if, on the contrary, it still continues muddy, it must be either again bunged up, and allowed to repose for a few weeks longer, or it

must pass through the process of fining. Its future treatment is similar to that already noticed under FOREIGN WINES.

The must of many of the strong-flavoured fruits, as black currants, mulberries, &c., is improved by being boiled before being made into wine. The flavour and bouquet of the more delicate fruits are either greatly diminished or entirely dissipated by boiling.

GENERAL FORMULÆ FOR THE PREPARATION OF BRITISH WINES.—1. *From ripe saccharine fruits.*—Take of the ripe fruit, 4 to 6 lbs.; clear soft water, 1 gall.; sugar, 3 to 5 lbs.; cream of tartar (dissolved in boiling water), 1¼ oz.; brandy 2 to 3 per cent., flavouring as required. If the full proportions of fruit and sugar are used, the product will be good without the brandy, but better with it. 1½ lb. of raisins may be substituted for each pound of sugar.

In the above manner are made the following wines:—Gooseberry wine, currant wine (red, white, or black); mixed fruit wine (currants and gooseberries, or black, red, and white currants, ripe black-heart cherries, and raspberries, equal parts), a good family wine; cherry wine; colepress's wine (from apples and mulberries, equal parts); elder wine; strawberry wine; raspberry wine; mulberry wine, whortleberry or bilberry wine; blackberry wine; damson wine; morella wine; apricot wine; apple wine; grape wine, &c.

2. From *dry saccharine fruit* (such as raisins).—Take of the dried fruit, 4½ to 7½ lbs.; clear soft water, 1 gall.; cream of tartar (dissolved), 1 oz.; brandy 1½ to 4 per cent. Should the dried fruit employed be at all deficient in saccharine matter, 2 to 3 lbs. of it may be omitted, and half that quantity of sugar, or two-thirds of raisins added. In the above manner are made date wine, fig wine, raisin wine, &c.

3. From *acidulous, astringent, or scarcely ripe fruits*, or those which are deficient in saccharine matter.—Take of the

picked fruit, $2\frac{1}{2}$ to $3\frac{1}{2}$ lbs.; sugar, $3\frac{1}{2}$ to $5\frac{1}{2}$ lbs.; cream of tartar (dissolved), $\frac{1}{2}$ oz.; water, 1 gall.; brandy, 2 to 6 per cent.

In the above manner are made gooseberry wine; bullace wine; damson wine.

4. From *footstalks, leaves, cuttings, &c.*—By infusing them in water, in the proportion of 3 to 6 lbs. to the gall., or q. s. to give a proper flavour, or to form a good saccharine liquid; and adding $2\frac{1}{2}$ to 4 lbs. of sugar to each gall. of the strained liquor. $1\frac{1}{2}$ lbs. of raisins may be substituted for each lb. of sugar.

In the above manner are made grape wine (from the pressed cake of grapes); English grape wine; rhubarb wine (from garden rhubarb); celery wine, &c.

5. From *saccharine roots and stems of plants.*—Take of the bruised, rasped, or sliced vegetable, 4 to 6 lbs.; boiling water, 1 gall.; infuse until cold, press out the liquid, and to each gall. add of sugar 3 to 4 lbs.; cream of tartar, 1 oz.; brandy, 2 to 5 per cent. For some roots and stems the water must not be very hot, as they are thus rendered troublesome to press.

In the above manner are made beetroot wine; parsnip wine; turnip wine, &c.

6. From *flowers, spices, aromatics, &c.*—These are prepared by infusing a sufficient quantity of the bruised ingredient for a few days in any simple wine (as that from sugar, honey, raisins, &c.) after the active fermentation is complete, or, at all events, a few weeks before racking them.

In the above manner are made clary wine ("muscadel"), (from flowers, 1 quart to the gall.); cowslip wine (from flowers, 2 quarts to the gall.); elder-flower wine (flowers of white-berried elder, $\frac{3}{4}$ pint, and lemon juice, 3 fl. oz. to the gall.); ginger wine ($1\frac{1}{4}$ oz. of ginger to the gall.); orange wine (1 dozen sliced oranges per gall.); lemon wine (juice of 12 and

rinds of 6 lemons to the gall.); spruce wine ($\frac{1}{4}$ oz. of essence of spruce per gall.); juniper wine (berries, $\frac{3}{4}$ pint per gall.); peach wine (4 or 5 sliced, and the stones broken, to the gall.); apricot wine (as peach wine, but with more fruit); quince wine (12 to the gall.); rose clove gillyflower, carnation, lavender, violet, primrose, and other flower wines (distilled water from the flowers, $1\frac{1}{2}$ pint, or flowers one pint to the gallon); mixed fruit wine; pine-apple wine; cider wine; elder wine; birch wine (from the sap, at the end of February or beginning of March); sycamore wine (from the sap); malt wine (from strong wort); and the wines of any of the saccharine juices of ripe fruit.

7. From *saccharine matter.*—Take of sugar, 3 to 4 lbs.; cream of tartar, $\frac{1}{2}$ oz.; water, 1 gall.; honey, 1 lb.; brandy, 2 to 4 per cent. A handful of grape leaves or cuttings, bruised, or a pint of good malt wort, or mild ale, may be substituted for the honey. Chiefly used as the basis for other wines, as it has little flavour of its own.

In all the preceding formulæ lump sugar is intended when the wines are required very pale, and good Muscovado sugar when this is not the case. Some of the preceding wines are improved by substituting good cider, perry, or pale ale or malt wort, for the whole or a portion of the water. Good porter may also be advantageously used in this way for some of the deep-coloured red wines. When expense is no object, and very strong wines are wanted, the expressed juices of the ripe fruits, with the addition of 3 or 4 lbs. of sugar per gall., may be substituted for the fruit in substance, and the water.

IMITATIONS OF FOREIGN WINES:*—

American Honey Wine.—From good honey, 21 lbs.; cider,

* The wines made from the subjoined formulæ, which are taken from Cooley's "Cyclopædia," were in demand at a time when the wine duties were high. They were sold as of British manufacture.

12 galls.; ferment, then add, of rum, 5 pints; brandy, 2 quarts; red or white tartar (dissolved), 6 oz.; bitter almonds and cloves, of each (bruised) $\frac{1}{4}$ oz.; powdered capsicum, 3 drs. This is also called "mead wine." With the addition of 3 oz. of finely grated unbleached Jamaica ginger, it forms the best American ginger wine.

British Burgundy.—By adding a little lemon juice, and a very small quantity of orris or orange-flower water, to "British port," the ingenious wine brewer converts it into "British Burgundy." British port is also made by mixing together equal parts of "British port" and claret.

British Cape.—1. (White.) Raisin wine, well attenuated by fermentation, either alone or worked up with a little cider and pale malt wort.

2. (Red.) British white Cape, sound rough cider and mulberry wine, equal parts; well mixed and fined down.

British Champagne.—1. From stoned raisins, 7 lbs. loaf sugar, 21 lbs.; water, 9 galls.; crystallized tartaric acid, 1 oz.; cream of tartar, $\frac{1}{2}$ oz.; Narbonne honey, 1 lb.; sweet yeast, $\frac{1}{4}$ pint; ferment, skimming frequently, and, when the fermentation is nearly over, add, of coarsely powdered orris root, 1 dr.; eau de fleurs d'oranges, $\frac{1}{4}$ pint; and lemon juice, 1 pint; in three months fine it down with $\frac{1}{4}$ oz. isinglass; in one month more, if not sparkling, again fine it down, and in another fortnight bottle it, observing to put a piece of double refined white sugar, the size of a pea, into each bottle; lastly, wire down the corks, and cover them with tin-foil.

2. As the preceding, but substituting 32 lbs. of double-refined sugar* for the sugar and raisins, with the addition of 3 galls. of rich pale-coloured brandy.

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* The purest sugar for the purpose of wine-making is that known as "Finzel's Crystallized White Sugar."

3. From amber hairy champagne gooseberries, English grape juice, or the stalks of garden rhubarb and lump sugar; with a little sweetbriar, orris, or orange-flower water, to impart a slight bouquet. The last forms what was formerly much in vogue as "patent" or "Bath champagne."

4. (Pink.) To either of the preceding add red currant juice, q. s. to colour; or 1 oz. of coarsely powdered cochineal to each 10 or 12 galls. at the time of racking.

British Claret.—1. Rich old cider or perry and British port equal parts.

2. To each gall. of the last add of cream of tartar, 3 drs., with the juice of 1 lemon. Sometimes $\frac{1}{4}$ pint of French brandy is also added.

British Cyprus.—From the juice of white elderberries, 1 quart, and Lisbon sugar, 4 lbs., to water, 1 gall.; together with $\frac{1}{2}$ dr. each of bruised ginger and cloves. When racked, add minced raisins and brandy, of each 2 oz.

British Hock, British Red Hock.—From cream of tartar, $1\frac{1}{4}$ oz.; tartaric acid, $\frac{1}{2}$ oz. (both in very fine powder); juices of the purple plum, ripe apples, and red beet, of each (warmed), 5 pints; lemon juice, 1 pint; with white sugar, $2\frac{1}{2}$ lbs. per gall.

British Madeira.—From very strong pale malt wort, 36 galls., sugar candy, 28 lbs., and cream of tartar, 3 oz.; fermented with yeast, 2 lbs., adding, when the fermentation is nearly finished, raisin wine, $2\frac{1}{2}$ galls.; brandy and sherry, of each 2 galls.; rum and brandy, of each 3 pints; after six or nine months, fine it down, and in another month bottle it.

British Malmsey.—From sliced or grated parsnips, 4 lbs.; boiling water, 1 gall.; when cold, press out the liquid, and to each gallon add of cream of tartar, $\frac{1}{2}$ oz., and good Muscovado sugar, 3 lbs.; ferment, rack, and add of brandy, 3 to 5 per cent. Good Malaga raisins may be substituted for the sugar.

British Red Moselle.—The last, coloured with clarified elderberry juice.

British Sparkling Moselle.—From rich cider apples (carefully peeled and garbled), pressed with one-fourth of their weight of white magnum-bonum plums (previously stoned), and the juice fermented with 2½ lbs. of double-refined sugar per gall., as champagne.

British Muscadel.—As "British sparkling Moselle," with some infusion of clary, or of the musk plant, to flavour it.

British Port, London Port, Southampton Port.—1. From red Cape, 2 galls.; damson or elder wine, 1 gall.; brandy, ½ pint, powdered kino, ½ oz.

2. Strong old cider, 6 galls.; elderberry juice, 4 galls.; sloe juice, 3 galls.; sugar, 28 lbs.; powdered extract of rhatany, 1 lb.; at the time of racking add, brandy, ½ gall.; good port wine, 2 galls.

3. Good port, 12 galls.; rectified spirit, 6 galls.; French brandy, 3 galls.; strong rough cider, 42 galls.; mix in a well-sulphured cask. ("Publican's Guide.")

4. Port wine, 8 galls.; brandy, 6 galls.; sloe juice, 4 galls.; strong rough cider, 45 galls.; as the last. ("Licensed Victualler's Companion.")

5. Cider, 24 galls.; juice of elderberries, 6 galls.; sloe juice, 4 galls.; rectified spirit, 3 galls.; brandy, 1½ gall.; powdered rhatany, 7 lbs.; isinglass, 4 oz., dissolved in a gallon of the cider; bung it down; in three months it will be fit to bottle, but should not be drunk until the next year; if a rougher quality is required, the quantity of rhatany may be increased, or alum, 5 or 6 oz. (dissolved in water), may be added.

British Sherry.—1. From Cape or raisin wine, slightly flavoured with a very little bitter-almond cake, or, what is more convenient, a little of the essential oil dissolved in alcohol. A very small quantity of sweet-briar, eau de fleurs d'oranges, or orris, is occasionally added by way of bouquet.

2. To each gallon of strong raisin must, add, when racking, 1 Seville orange, and 3 or 4 bitter almonds, both sliced. By omitting the almonds, and adding 1 green citron to each 2 or 3 gallons, this forms "British Madeira."

3. Very strong pale malt wort, 36 galls.; finest Muscovado sugar, 1 cwt.; yeast, 1 pint; ferment; on the third day add of raisins (stoned), 14 lbs., and in another week rectified spirit, 1 gall.; rum, ½ gall.; and grated bitter almonds, 1¼ oz.; bung down for four months, then draw it off into another cask, add of brandy, 1 gall., and in three months bottle it.

4. Teneriffe, slightly flavoured with cherry-laurel or bitter almonds, forms "British sherry," either alone or diluted with an equal quantity of Cape or raisin wine, or good perry.

British Tokay.—To good cider, 18 galls.; add, of elderberry juice, ½ gall.; honey, 28 lbs.; sugar, 14 lbs.; red argol in powder, ¾ lb.; crystallized tartaric acid, 3 oz.; mix, boil, ferment, and, when the active fermentation is complete, add of brandy, 1 gall., and suspend in the liquid, from the bunghole, a mixture of cassia and ginger, of each ½ oz.; cloves and capsicum, of each ¼ oz.; the whole bruised, and loosely enclosed in a coarse muslin bag. It will be ripe in twelve months.

Some of the preceding formulæ, are said, by skilful management, to produce fair imitations of some of the imported wines; but many of the British fruit wines possess an equally agreeable flavour, and are frequently more wholesome. All British wines require to be kept at least a year to mellow. Much of the superiority of foreign wines arises from their age.

Sack.—(From SEC, Fr. "dry.") A wine used by our ancestors, supposed by some to have been Rhenish or Canary; but, with more probability, by others, to have

been dry mountain vin d'Espagne; vin sec—(Howell, "French and English Dictionary," 1650). Falstaff* calls it "sherris sack" (sherry sack), from Xeres, a sea town of Corduba, where that kind of sack (wine) is made.—(Blount.) At a later period the term came to be used as a general name for all sweet wines.

* In Shakespeare's day sack was occasionally adulterated with lime, as we learn from Falstaff's speech to the Drawer: "You rogue, there's lime in this sack."

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